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LECTURES

ON THE

PRINCIPLES OF SURGERY.

DELIVERED AT

BELLEVUE HOSPITAL MEDICAL COLLEGE.

BY

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NEW YORK:

D. APPLETON AND COMPANY,

1, 3, AND 5 BOND STREET.

1884.

EDITOR'S PREFACE.

During the last fifteen years of his life Dr. Van Buren was Professor of Surgery in the Bellevue Hospital Medical College, and for nearly twenty years previously he had been Professor of Anatomy and of Clinical Surgery in the University of the City of New York.

His success was as great in this field as it was in others, and was earned by the most thorough and careful preparation for every course and every lecture. It was always his practice to prepare a syllabus, and often to write out a lecture in full before its delivery. During the last years of his life he wrote and rewrote many of these lectures, arranged them, and added to them in such a way as to make them a systematic exposition of the subject as he sought to present it to his classes.

From these manuscripts this book has been printed, without other changes than a few verbal ones, and without addition. It is offered, not as a complete treatise on the principles of surgery, prepared with the thoroughness and attention to detail that all have recognized and learned to expect in whatever Dr. Van Buren gave to the press, but simply as that presenta-

tion of them which he, in his large experience as a teacher, thought best fitted to be of service to the student and to the practitioner who returned to take his place upon the benches of the lecture-room. And, in thus giving to these notes a permanent form, Dr. Van Buren's friends feel that they not only pay a proper tribute to his memory, but also do a service to the profession, and especially to those who have received their surgical education from him.

L. A. S.

September, 1884.

CONTENTS.

CHAPTER I.

Science and art of surgery—Relation of medicine and surgery—Specialties—Definition of surgery; of surgical affections—Study of surgery—The subjects of this course—Internal injuries.

In beginning the study of surgery, gentlemen, it is well that we should recognize that it is the oldest branch of the healing art; for external injuries of the human body, obvious to the sight, and appealing to the sympathies of the beholder, demanded and received the ministrations of the benevolent, even when these included only the pouring of oil and wine into wounds, long before there was any but the crudest knowledge of chemistry or anatomy to suggest rational remedies for fevers or internal maladies.

The results of these efforts to minister to external injuries have slowly and gradually led to an acquaintance with the extent of nature's own resources in remedying wounds and hurts, and have taught us—mainly by experience—the means whereby we may assist nature. The knowledge of these means, when systematically elaborated, constitutes, in fact, the *science of surgery;* and the best modes of employing them in an individual case constitute its *art.* Thus the art and science of surgery have gradually grown from small beginnings into the imposing proportions which they now present to us for investigation and study. In the days of Greece and Rome it was regarded as the religious duty of the invalid who had recovered from

an illness to place a votive tablet in the temple of Æsculapius, the god of physic, on which was inscribed a record of the means which had seemed to bring about the desired result. Hippocrates refers to remedies thus brought into repute.

There is no real distinction between medicine and surgery; they are both founded upon observation of nature and study of the same branches of natural science, whether applied to the cure of disease or of the effects of injury. Chemistry, physiology, and especially anatomy constitute alike their foundation.

We speak of surgery as a department of medicine in the same sense that we speak of orthopædy as a branch of surgery. It is the accidental social conditions and legal enactments in different communities which have begotten in the popular mind the idea of a difference between the functions of the physician and the surgeon. In England, for example, this has occurred in consequence of governmental statutes providing for each under distinctive titles, and also from the English fashion among those following useful pursuits to form themselves into guilds or companies with limited and defined duties and rights. *But, wherever the highest scientific culture has prevailed*, medicine and surgery are regarded as identical.

Even in ancient Rome, as we are told by Dr. John Watson, of the New York Hospital, in his learned history of the medical profession in ancient times, surgery and medicine proper, although sometimes taught or practiced separately as specialties, were never disconnected by the educated physicians of antiquity. In fact, they rejected most of the specialists of their day as impostors. Of these illegitimate sons of Æsculapius he says: "The numbers and pretensions were as great in ancient as in modern times, and they were just as likely to receive the countenance and favor of the upper classes of society. Chosroes, King of Persia, was the patron of the famous quack Uranus, and Nero was the supporter

of the audacious Thessalus, who, like Paracelsus, repudiated all learning as useless, and, like Hahnemann in more recent times, asserted higher laws and assumed to be above all science, and opposed to all who had ever gone before him." "Pliny and Galen," says Watson, "are justly severe on these ancient impostors; and, if we can credit the account of them given by these authors, the host of industrialists, oculists, rhinoplasts, dentists, bone-setters, herniotomists, lithotomists, gelders, abortionists, and poison-venders pervading Italy, France, and Spain throughout the middle ages—before whom the modern group of pretenders grow pale and insignificant—were at least equaled, if not exceeded, in ignorance by the quacks of Rome" under the empire.*

Thus, we observe, history repeats itself.

In the steadily increasing scope and range of modern medical science the existence of what are called *specialties*—i. e., subjects to which a practitioner devotes special and more or less exclusive attention—has come to be regarded as a recognized and legitimate necessity. In our day this has grown to be the case notably in the great centers of population, where opportunities for gaining experience and practice are concentrated in consequence of the accumulating numbers of those requiring aid. The attainment of an equal degree of skill in all the branches of medicine has become obviously beyond the capacity of the individual. Hence the need and the justification of a division of labor. In a great city, if a specialist, by honorable means, can command full occupation, he is justified in devoting himself exclusively to his specialty.

The modern specialist, however, bases his claims to respect upon the possession of a liberal education, which includes a certain degree of familiarity with all the branches of medicine; and, in addition to this, upon a certain personal fitness and opportunity for

* Anniversary discourse delivered before the New York Academy of Medicine, November, 1855.

acquiring skill in some particular branch. But his specialty, to be exercised legitimately, must be the outgrowth of an education possessing honest claims to completeness, and, at the same time, of a fair capacity, if necessity should arise, to practice the medical profession in any of its branches. Except on these conditions, a specialist of the greatest ability may find himself deficient in clinical capacity, and unable to take a broad, able, and comprehensive view of the requirements of a given case of disease, even when entirely within his specialty. An ophthalmic surgeon of acknowledged skill once sent a patient to me for consultation who was suffering from paroxysms of intense pain of the eye, in whose case, in consequence of their constant recurrence, he had begun to fear serious brain disease—possibly syphilitic. Nothing was found, however, but an ordinary brow-ague—a neuralgia of the supra-orbital nerve—and this yielded promptly to the influence of quinine. This specialist, who had studied his art most successfully under Donders, in Germany, had not seen enough of malarial disease in this country, where it is so common, to enable him to recognize with certainty one of its ordinary and well-marked manifestations.

Nor, I may add to what I have said, is it a wise course for an aspirant for medical honors to select a specialty at the beginning of his studies and look mainly to this as his object, neglecting collateral subjects beyond what is absolutely necessary for the attainment of a degree. *The student who entertains the ultimate purpose of becoming a specialist must grasp the whole curriculum fairly and honestly, or he will become inevitably a fractional member of the profession, and can never practice a specialty on a legitimate basis.* The degree of Doctor in Medicine covers equally all the branches of medical knowledge; and special practical skill in any one of these branches is only to be fully attained by the individual efforts of

the aspirant *after the degree has been conferred.* When special skill has been thus legitimately gained and successfully proved, the specialist is properly called an "expert" in his department.

In this sense surgery may be regarded as a specialty, and the surgeon as an "expert" in surgical affections.

But a good surgeon can never cease to be also a fairly good physician. Special surgical skill in no respect excludes or dispenses with purely medical knowledge; it is, in fact, complemental to the ordinary acquirements of the physician.

This is the light in which surgery is regarded in Germany, Austria, and France, as well as in our own country. The titular distinctions which obtain in England involve no essential differences in these respects; they are the result of local educational methods, protected by legal provision, to meet local requirements, similar to that which, in France, licenses a class of women as midwives, mainly to meet the wants of the poor.

The traditional inferiority once attached to the function of the surgeon, derived from the more mechanical requirements of his craft, and their occasional performance in ancient times by inferior persons, no longer exists. On the contrary, to excel in his special department at the present day, the surgeon must possess *all the qualifications of the physician*, and, besides these, certain other qualities in addition. Tact and dexterity in *hand-work* and courage to face emergencies do not exclude in any degree the necessity for a high capacity in the way of *brain-work.*

The surgeon sees more clearly the changes which take place in injured and inflamed parts, because they are for the most part nearer to the surface of the body, being in some cases partially, in others entirely, subject to his immediate inspection. Thus, in a wound or after the removal of a tumor, the parts involved are under the eye or within reach of the finger; or, as in

a gunshot wound, accessible, in most instances, by exploring instruments; or, as in fracture, by direct or indirect palpation.

The pure physician, on the other hand, is compelled, most frequently, to rely entirely upon *symptoms*, and to judge of what is taking place in a disease of an internal organ by this more indirect and circumstantial evidence. When this sort of evidence becomes more direct and tangible, however, as when there is bulging of the intercostal spaces in empyema, the physician adopts the surgeon's methods and makes an opening; just as the surgeon, under analogous circumstances, to determine if his patient's fever depends upon a serious degree of blood-poisoning, proceeds to measure the temperature of his blood by a thermometer. In fact, the mental processes, the devices, and the clinical training by which the exact truth is sought for are in either case closely similar, if not identical.

It is obvious that, through the greater facilities for exploration in surgical cases, the conclusions of the surgeon should be more certain and accurate than those of the physician, just as his remedies are often more prompt and heroic. Nevertheless, there are surgical cases of daily occurrence which require as careful observation and accurate logical deduction from premises in the form of obscure or equivocal symptoms as those presented by any medical case. There is, therefore, in surgery as in medicine, the same necessity for accurate foreknowledge of pathological changes likely to occur; the same power of logical reasoning is required to trace effects, in the form of disease, to their rational causes; and, for the most part, similar resources in the way of treatment are employed.

It is a popular, I may say a vulgar error, which is quite prevalent in regard to the surgeon, that his highest function is attained in a brilliant operation. But, in truth, a still greater degree of merit is shown in the

avoidance of an operation, when this is possible, by means of fuller pathological knowledge.

It may be said, without any fear of contradiction, that, since the introduction of anæsthetics into the practice of surgery, any man with fairly acute senses, an honest purpose, and a sound and promptly acting mind, who has made himself accurately familiar with anatomy, may make a good surgeon of himself by means of adequate study and training, and may acquire the power of saving life in what are called surgical emergencies.

It may be proper here to ask more critically, What, then, is surgery?

It is the name given to that department of the science and art of medicine which takes charge of all those diseases and injuries requiring in their treatment especial training or dexterity in the use of the hands, or of instruments to supplement the hands. In other words, the practice of surgery demands not only *head-work* but *hand-work.** As in the experiments of chemistry, and in experiments on animals—so valuable in the study of life—and in the dissection of the human body after death, the quality of mechanical skill and dexterity is in surgery of great avail. Thus, for the proper treatment of a broken bone—for a fracture is, perhaps, the best type of a surgical affection—a certain tact in the use of the hands is required in manipulating the injured limb, in feeling for *crepitus* in order to establish the diagnosis, and in adjusting or "setting" the fragments accurately. In the operations by which cataract is cured, the most delicate instruments are required, and careful training in their use; in reducing a stone in the bladder to minute fragments and removing them to the last and smallest piece without injury to the delicate surface of the organ, the same trained skill is necessary to command a successful result.

* The word, as first employed, was *chirurgery*, derived from the two Greek words *χείρ*, the hand, and *ἔργον*, work.

And yet, in addition to this manual dexterity, the surgeon who undertakes the treatment of the case of fracture, as I have already insisted, must possess full medical knowledge; he must be able to recognize the condition as to soundness, or otherwise, of his patient's internal organs—of his brain, heart, lungs, and kidneys. He must be able to detect the first approach of delirium tremens—so liable to occur in the case of a drinking-man who breaks his leg—or to recognize the symptoms of any intercurrent medical disease, such as pneumonia or typhoid fever.

If a question as to the necessity of amputation should arise, the surgeon must be an adept in auscultation and percussion in order to ascertain the condition of the patient's heart and lungs; and he must be able to examine the urine, to ascertain if the kidneys are free from organic disease; for accurate information on these points is *absolutely necessary* to determine the propriety of undertaking any capital operation.*

The want of this medical skill would expose the surgeon to serious errors of judgment, and his patient to greatly increased danger of loss of limb or loss of life. The same necessity for medical training is required by the ophthalmic surgeon before deciding upon *his* delicate operations. To undertake the extraction of a cataract in a patient with Bright's disease or diabetes would be a blunder; and I have knowledge of more than one instance in which life has been lost by undertaking the new operation for stone where advanced disease of the kidneys was present, and, in other instances, where practiced skill and training in the use of the necessary instruments in this operation have been lacking.

It is only in large cities that experts on auscultation

* The surgeon should be specially familiar with the diagnosis of fever, for, in the several phases of septic blood-poisoning which constitute the surgical fevers, he is dealing with the fundamental facts in the pathology of the febrile condition.—*Wilks on Pyæmia.*

and in urinary analysis can be relied upon to supplement a want of this knowledge on the part of the surgeon. Elsewhere, he must be prepared to rely upon himself.

I cite these examples, in answering the question, What is surgery? to illustrate the truth that surgery is a branch of the medical art, and not a separate department of knowledge.

The interdependence of pure medicine and surgery becomes more obvious, and their identity more indisputable, as our knowledge advances.

Both of these branches of medicine, as we have seen, are founded upon the exact facts in the cardinal branches of *anatomy*, *physiology*, *histology*, *pathology*, *physics*, and *chemistry*. These facts are applied, in the one case, to what are called "medical diseases," i. e., to those arising from faulty environment, inherited diathesis, or blood-poisoning—from whatever cause—affecting internal organs; in the other, to tumors and outgrowths, and the lesions produced by wounds and injuries, which constitute surgical diseases. The application of the exact knowledge derived from these and other sources constitutes the *science*, or what is more commonly called the *principles*, of surgery. The student seeks the fountains of his scientific knowledge in cultivating assiduously these cardinal branches. It is well that we should recognize that whatever there is of exactness in medicine or surgery is derived from one of these departments of natural science.

Having recognized the true relations which exist between surgery and medicine, we may next seek to determine *what are properly called surgical affections.*

They are simply those which require surgical remedies, e. g., the use of instruments, apparatus, or operation, in their treatment.

Under this denomination belong *deformities*, whether *congenital*, such as hare-lip, imperforate anus, strabismus, club-foot, and spina bifida, or *acquired*, such

as contractions following burns, curvature of the spine, wry-neck, etc.

Then there is a class of *nervous affections*, mainly the result of morbid reflex action or of hysteria, which are amenable to surgical remedies, and generally spoken of as *neuroses;* they are for the most part functional, and not due to organic disease of the nerves. I may mention, as examples of these surgical neuroses, spasmodic stricture of the œsophagus, curable by passing a bougie through this canal; the same condition of the voluntary muscles surrounding the deep urethra, sometimes cured by incision of a narrow meatus; reflex twitchings and muscular contractions, and even more serious symptoms, in male children from adhesion of the prepuce to the glans penis, curable by circumcision. Most surgical neurotic affections take the shape of muscular contractions or of painful affections, mainly of the joints, and especially in females. In the latter they are very often of the nature of hysteria, although generally referred to the surgeon for treatment.

But by far the largest proportion of surgical affections are included under the head of *wounds and injuries*—what are usually styled "traumatic lesions," or simply *traumatisms.* These are the result of cutting, crushing, tearing, or burning of the living tissues—the effect, in short, of mechanical or chemical violence. *The term "wound" includes the idea of a division of the superficial tissues, of a visible solution of continuity;* in the term "injury" this idea is not necessarily present. Thus, a fracture is an "injury"; it may or may not be accompanied by a wound. Tumors or outgrowths are invariably regarded as surgical affections. So are external aneurisms and diseases of arteries.

But the line that separates medical and surgical affections is of necessity very loosely drawn. Internal aneurisms, as of the thoracic and abdominal aorta, are usually left to the physician; but even here the gal-

vanic current has been brought to bear upon them. A tumor in the iliac fossa may be a cancerous mass, or simple impaction of fæces. I have more than once been summoned to a case of abdominal tumor which proved to be a mass of impacted fæces, removable by cathartic medicine. Syphilis, which is by common consent referred to the surgeon, because its lesions are for the most part external, is essentially a blood disease closely analogous to the eruptive fevers, and amenable to medication by drugs. Obscure affections of the nervous centers are often due to constitutional syphilis. Yet skin diseases, many of which require only local treatment, are, as a rule, classed as medical. There is a medical erysipelas, formerly called "idiopathic," and a surgical erysipelas, distinguished usually by the term "traumatic."

But, as a rule, wherever the trained eye or hand is required, or a clinical familiarity with external lesions, whether purely surgical remedies are called for or not, the surgeon is appealed to.

Again, in connection with the treatment of the large and important class of wounds and injuries, there are complications constantly arising, foremost among which is the exceedingly common condition known as inflammation, which, although liable to occur in internal organs, is most frequently regarded and treated of among the surgical affections, with its accompaniments of abscess, ulceration, and mortification; and in this category are to be included traumatic or surgical fever, pyæmia or surgical typhus, tetanus or lock-jaw, and septicæmia in many of its phases.

We may next inquire how surgery is to be studied to the best advantage?

Besides the exposition of the subject by individuals of more or less experience in lectures—didactic, demonstrative, or clinical—the student is to inform himself by *reading;* he requires books of reference—i. e., dictionaries and text-books—and he should also have ac-

cess at will to monographs and authoritative works on special subjects, such as are found in libraries.

Didactic lectures should give their proper weight and relative importance to the several divisions of the subject as they come up for consideration, and they should carefully consider the value of the doctrines of the day and the theories they involve, while setting forth systematically, in regular order, the present condition of surgical science.

Demonstrative lectures should show the different forms of surgical apparatus and instruments required in the treatment of surgical diseases, the mode of applying them, and the best methods of performing the various operations of surgery.

In *clinical* lectures, surgical remedies are applied to the living body, and the eye rendered familiar with the aspects of surgical diseases, and, as far as possible, with the effects of surgical operations and surgical treatment.

To profit by clinical lectures, the student should strive to follow each case as far as it is possible to do so, to keep a note of it, and to ascertain its result. If the result should not be successful, it is all important to find out the cause of failure of the treatment, and to witness the post-mortem examination, if possible.

I have known a student ignore an unsuccessful result of a case through a mistaken sense of loyalty to his teacher. *This, although an honorable impulse, is not the genuine scientific spirit, which is loyal only to one end, viz., the truth.* In science there are no personalities, and the individual sinks into nothing in comparison with its paramount object, the attainment of absolute truth.

It is in this way only that clinical lectures are of real practical utility, and that they confer lasting benefit.

Cases which have been thoroughly observed constitute the salient points of our experience, and are in-

delibly impressed upon the memory for future reference. It is not necessary that a case should be in any respect unusual or remarkable to be thus noted and treasured up; but simply that it should be typical in its way, and, above all, complete. I find myself constantly recurring to cases of which I made careful notes in La Charité Hospital, in Paris, more than forty years ago, in the service of Velpeau.

Actual *bedside* study of cases of disease is a most fertile source of information to the surgical student; but the *dramatic element* which belongs to the operations of surgery must not be allowed to monopolize too great a share of attention, to the exclusion of practical details which are of equal if not greater importance, and of a clear perception of the actual practical value and results of the treatment employed.

In *reading*, which is looked upon as one of the most important duties in the study of surgery, it is better—rather than to confine one's self to a continuous perusal of any work with the purpose of "reading it through,"—to turn to books of reference in connection with some subject in which the mind has become interested in the lecture-room or hospital. Information sought in this way is more likely to become fixed in the memory. According to Horace, Minerva is propitious only in this mode of study. It is, moreover, the mode of reading necessarily adopted by the practitioner.

Every student of surgery should have access to a *private preceptor*, to whom he can apply for guidance as to the selection of authors for reference in reading, for the solution of obscure questions as they arise, and for advice at all times; for we have it, on Lord Bacon's authority, that "he that questioneth much shall learn much." One of the duties of the private preceptor is frequent examination of his pupil to ascertain the degree of information he is deriving from his studies. This duty, when the student leaves home for a distant

school of instruction, is transferred to a practiced expert, who gives it his especial attention.

The time is not far distant when the surgical student will be compelled to follow courses of experimental research in a surgical laboratory, for, as in physiology, experiments on animals are of great value, for example, in studying the processes of repair in the different tissues. Thus, it was by experiments upon living animals that the ability of the periosteum to reproduce bone, and of divided nerves to unite and resume their functions, was demonstrated.

John Hunter first laid the foundations of surgical science, in his laboratory, by experiments upon animals. The success of his famous experiment in which he grafted the spur of a chicken-cock into his comb, where it grew permanently, foreshadowed the possibility of the recently adopted practice of skin-grafting, by means of which large chronic ulcers, otherwise incurable, have been made to heal, and in this way a necessity for amputation has been prevented.

These are the best methods by which the capabilities of repair and the tolerance of injury by living tissues can be learned, and the possibilities in the range of surgical operations increased and extended. Hunter had frequently tied the arteries of dogs before he undertook the same operation upon man for the cure of aneurism, which was his greatest achievement in operative surgery.

Imitating in this way the methods of the physiologist, we have learned, by scrutinizing the processes of life by experiments on living animals, the several modes in which nature heals wounds. The experiments of Sir James Paget on the tendons of living rabbits, illustrating the mode in which they heal after subcutaneous tenotomy, have demonstrated at the same time to the physician the mode in which connective tissue is developed in the shape of false membranous adhesions between the surfaces of the pleura after

pleurisy. Cornil and Ranvier, by injecting a solution of nitrate of silver into the peritoneal cavity in living rats, and then scrutinizing under the microscope the changes that follow in the delicate membrane of the omentum, have taught us the mechanism of pus formation in the graver cases of peritonitis, and of simple adhesion by means of plastic lymph in the milder cases which get well. Examinations of bodies after death have taught us that peritonitis, terminating in pus formation and causing death, results from blood-poisoning, as by septicæmia; and the bold and successful advances of surgery in the removal of ovarian tumors, and in other surgical operations involving the peritonæum, have demonstrated that with skillful antiseptic precautions we can avoid blood-poisoning and limit the process of repair, even in the most extensive wounds, to the simple organization of plastic lymph, and thus secure prompt and certain recovery. These facts, which are of recent development, are of equal interest to the physician and the surgeon, and serve again to show that their science is one and the same.

Our increasing claims to exactness in professional knowledge are based also, in a great degree, on the use of *instruments of precision* which recent advances in physical science have furnished to medicine; and with these the student of surgery must make himself familiar. By instruments of precision I mean the *microscope*, which in the last half century has taught us, as matters of certainty, details in pathology which were only guessed at vaguely by Sydenham and John Hunter; the *thermometer*, which, by telling us certainly the temperature of the blood, furnishes most valuable information as to the condition of that all-important constituent of the organism; the *ophthalmoscope*, by means of which we can observe the state of the capillary circulation in the eye; the *sphygmograph*, by which we can measure the quality and force of the heart's action far more accurately than by the fingers on the pulse; the

aspirator, with which we can safely penetrate the great cavities of the body and ascertain the nature of effused fluids.

To this same category belong instruments for measuring accurately the shape and size of the body in its different parts, which afford us reliable data as to changes resulting from disease and deformity, such as the *stethometer*, for example, which, by measuring the chest externally, gives evidence of change of shape from former pleurisy. Similar measurement of the limbs brings to light evidence of congenital difference of length, which has been found to exist in many persons, and which might be wrongly attributed to previous fracture with shortening.

There are other devices, suggested by chemistry and constantly employed in treatment, which are to be mastered by the student: the use of electricity in its various modes of application; of galvanism in the treatment of internal aneurism, already alluded to; of calcric in the form of Paquelin's thermo-cautery, by means of which we can, with entire facility, divide the tissues with a red-hot knife in our ordinary operations; and the employment of cold, in the form of the bath, for lowering the temperature of the body when the blood has become too hot.

It is obvious that we seek, at the present day, to advance our knowledge in medicine and surgery, as in the other branches of natural science, by a closer and more careful scrutiny of simple natural facts, rather than by the metaphysical speculation on insufficient premises which was so commonly employed in former days. I know of no better illustration in proof of this than the recent advances which have been gained by the use of improved optical apparatus in discovering the poisonous agency of very minute organisms in causing blood-poisoning, and the recognition of the influence of the so-called antiseptic agents in antagonizing them.

Of all considerations in connection with the study

of surgery, the first and most important is, undoubtedly, to secure a sound foundation of anatomy, histology, and pathology. The surgeon requires not only a knowledge of descriptive and physiological anatomy, but also, and especially, of surgical or relative anatomy. He must dissect the several regions in which surgical operations are most frequently called for, with especial reference to the relations of the parts involved in these operations. This is the kind of knowledge that confers coolness of the head and steadiness of the hand upon an operator. Without it, no amount of ability or study will render a surgeon safe and sure in his special calling. The late Valentine Mott, who occupied so high a place among American surgeons as an operator, was in the habit of rehearsing operations of importance in the dead-house before performing them upon the living body, and of reviving, at the same time, his great familiarity with the anatomy of the region; and this habit he kept up, to my knowledge, until the age of sixty-five.

Practical histology and pathology are equally necessary for him who aspires to be a scientific surgeon, and not an operator only. It is this wider knowledge, in addition to its peculiar achievements in the cure of disease, that has raised surgery to its present position. Two hundred years ago the surgeon, save in exceptional instances, was the humble and often unlettered assistant to the physician. Only about a hundred years ago surgery began to assert its equal rights to respect as a scientific pursuit, mainly in the person and by the superior genius of John Hunter. At the present time it possesses, by right of discovery, an equal share in the knowledge which constitutes the science of medicine. It has demonstrated the inestimable advantages of anæsthetics, and is now proving the even greater value of antiseptics.

To sum up, I would therefore ask you to regard surgery as a branch of knowledge which legitimately

includes all of the science required by the pure physician, with the addition, in him who aspires to practice its art with the highest degree of success, of certain other indispensable qualities. In addition to a more perfect and practical familiarity with the details of surgical anatomy, the surgeon, I conceive, should possess, in a large degree, physical vigor, courage, presence of mind under circumstances of danger and excitement, and a fair amount of manual dexterity.

As we have seen, surgery is properly regarded as a specialty, and its practice as a specialty can not be wisely undertaken by every one who studies medicine, unless fitted both by nature and by especial training in study for its successful pursuit.

I have not spoken of surgery as a specialty unadvisedly. As I have already intimated, it should not be specially aimed at by the beginner until after he has gained a fair basis of knowledge of the elementary branches and attained a position to form a judgment as to his natural fitness for the practice of surgery. I make this remark because there is a certain dramatic attractiveness about the operations of surgery which charms the student; and the proportion of generous aspirants who propose to themselves to become practical surgeons is invariably much larger than the number of those who actually succeed in doing so. It is wiser, in my experience, not to give way to this early preference, but to wait patiently until a greater familiarity with the practical branches to be gained in subsequent years of study has furnished a basis for more mature judgment.

Lister began his scientific career, after leaving college, by studying physiology, which is certainly the best preliminary for the study of medicine. As a physiologist he became proficient in the use of the microscope, and in the experimental methods of the physiologist. By this route he was led into the general study of medicine, in which he had conceived a great interest; and it was only by subsequent events

that his attention was seriously diverted to the special pursuit of surgery.

To this deliberate development of a final purpose I am disposed to ascribe the successful career of this eminently scientific surgeon, whose name will certainly be remembered longer in the world's history than that of any other surgeon now living. Lister will not have advanced surgery by devising brilliant operations; but his special methods—the result of inductive reasoning from discoveries made by other observers in another branch of science, slowly, gradually, and laboriously introduced and established after the unremitting perseverance of nearly a score of years—will have added very largely to the certainty of success of all surgical operations, and will have certainly increased the average duration of human life.

This is an illustration of the genuine and legitimate advance of the science of surgery, and of the advantages to be derived from proper methods of study.

As to the *order to be pursued in these lectures*, I propose to take up at first the subject of *wounds and injuries*, which comprises so large a proportion of surgical affections. This will necessarily include the process of repair, and certain phases of the condition of *inflammation.*

In the next place, there is a category of important surgical maladies which may be classed as complications liable to attend or follow wounds and injuries, which will necessarily occupy our attention. These include the *neuroses and unhealthy inflammations*, such as tetanus or lock-jaw, erysipelas, and the various forms of fever from blood-poisoning.

Finally, the subject of *degenerations* and the various forms of *morbid growths, or tumors*, will complete the course. These will comprise the subjects of our study, and what I shall have to say upon them will be alternated with demonstrative and clinical lectures occupying fully the time you are able to devote to surgery.

Our earliest duty is to inquire into the mechanism by which the process of repair is accomplished, and to explain the phenomena that attend the healing of wounds, seeing that for the cure of wounds the surgeon is held especially responsible. The mechanism of the process of repair is one of the most important lessons to be learned in surgical pathology.

It is to be observed, in the first place, that it is not the surgeon by whom the wound is healed: it is by the processes of nature that this end is accomplished. But the surgeon must be very familiar with all the details of this "process of repair," as it is usually called; he must know exactly what influences favor it and what retard it, for in the possession of this knowledge lies the groundwork of his skill, and all his pretension to science.

We should never lose sight of the fact that surgery is a branch of natural philosophy, and that it is from a constant and close study of natural phenomena that we derive all our information. John Hunter, the model surgical philosopher of the last century, set us the example of minute and careful study of the natural phenomena which attend the healing of wounds; and the ability and, above all, the honesty of the spirit with which his experiments were carried out have given him his enduring reputation. Hunter's great merit lay in careful and truthful observation; and this is the reason why we are so constantly recurring to him as an authority. In his truth as an observer lies the secret of his greatness, and not in his reasoning powers, although they were of a high order. In following his methods of experimental observation, which are still in force, and will continue to be the source of all the greatest improvements in surgery, if we are sufficiently modest and laborious, we may also make ourselves correct and trustworthy observers, and this is all we need to aim at. *The truth flows naturally from well-observed facts, and it is wiser not to be too anxious to reason*

out theories; if we make ourselves sure of the facts, theories will take care of themselves.

A remarkable error, by which we may profit, was committed by Hunter himself, in consequence of false reasoning in adopting a conclusion from an insufficient basis of facts.

The great surgeon was especially interested in the *venereal diseases*, upon which he wrote a separate and an elaborate monograph. Concerning the poisons which cause these diseases, conflicting opinions were held then as now; and, to throw light on the subject, Hunter, as usual, resorted to experiments. Among others, he one day inoculated himself on the arm with gonorrhœal discharge from an inmate of the Newgate prison, of which he was surgeon. As a result of this inoculation, well-marked constitutional syphilis was subsequently developed. A circumstantial history of his case, observed and recorded by himself, is contained in the edition of his works edited by Dr. Babington, of Guy's Hospital, which edition was afterward translated into French by Ricord, at the beginning of his career.

In consequence of this unexpected result, Hunter allowed himself to formulate the conclusion that *the virus of gonorrhœa is identical with that of syphilis —an error which he held to the end of his life, and by which the advance of knowledge concerning this important subject was greatly retarded.*

The errors of judgment committed by men of exceptional ability give rise to evil consequences proportionate to the greatness of their authors, who, having gained the attention and admiration of their fellow-men, can more readily and more seriously lead them astray.

It was not until half a century later that this conclusion as to the identity of syphilis and gonorrhœa, too precipitately adopted by Hunter, was finally demonstrated to be false by fuller and more extensive experimental research undertaken by Ricord himself;

and it is by this important gain for science that the name of Ricord has been made famous. Ricord's main achievement was to prove to the world that his master was in error, and that syphilis and gonorrhœa are certainly separate and distinct diseases, and caused by entirely different poisons.

It may not be unprofitable to note here, as showing to what extent the powers of the individual are overtaxed in the pursuit of truth, that the successful labors of Ricord in his specialty prepared the way for another step in advance, which he, although a trained and acute observer, failed himself to make. Another half century had elapsed, after Ricord's exposure of Hunter's erroneous conclusion, before it was demonstrated by Bassereau, one of Ricord's pupils, who followed the same plan of experimental observation, *that the virus of syphilis is distinctly different from the poison which produces the contagious venereal ulcer, or chancroid; and this novel truth is now slowly making its way to general acceptance.* This truth is: The entire lack of identity between the initial symptom of syphilis—usually called hard, or infecting, chancre—and the contagious venereal ulcer, or chancroid.

Under the title of *wounds and injuries*, the consideration of which we are about to commence, are also included (besides the cuts and bruises and burns of the surface of the body, and the fractures and dislocations which affect the skeleton) a distinct class of lesions which are denominated "*internal injuries.*" The liability to serious and even fatal injuries of internal organs, which are for the most part of delicate texture, and only partially protected in the great cavities of the body—as, for example, laceration of the liver, lungs, spleen, or even of the brain, without apparent external lesion—is very likely to be underestimated, or even to pass unrecognized.

An opinion as to the gravity of any given surgical

accident might be seriously unsound if this liability to internal injury were not kept in view.

The singular elasticity and power of resistance of the external integument, familiar as we are with its more obvious qualities of softness and delicacy, are deceptively great. This is well illustrated by the condition of a limb over which the wheel of a railroad car has passed ; its muscles, and even its bones, are crushed or torn, while the external integument may show hardly an abrasion, merely a discolored band marking the course of the wheel. In a case of this kind the friends of the patient are always slow to believe in the necessity for amputation, because the tough skin so thoroughly masks the extensive destruction within.

Similar obscure lesions of the delicate viscera of the great cavities are not rare ; and in the difficulty of estimating correctly the force applied in an accident, and in the absence of any, or but slight, marks of external violence, the "internal" injury is very likely to be overlooked, or its gravity to be underestimated.

A woman was brought to the hospital with the statement that she had been kicked in the belly. There was but slight evidence of external bruising, but she was in the condition known as *collapse*, and died, without reaction, in about twelve hours. At the inquest it was found that the bladder had been ruptured and its contents extravasated, partly into the peritoneal cavity.

While driving through one of the narrow streets of the eastern part of the city I saw a drunken man, who was staggering along the sidewalk, fall suddenly across the gutter just in front of a coal-cart which was slowly advancing. There was an outcry, and the cart was stopped just, it seemed to me, as the wheel was about to touch the man's body. On visiting the hospital the next day, I found that this man had been brought there on a litter, and that he had died in a few hours, the cause of death having been entered on the books as "exhaustion." The post-mortem examina-

tion revealed a laceration of the liver, and a large effusion of blood into the cavity of the peritonæum. In this case there was no perceptible abrasion or bruise externally, and the wheel seemed to have barely touched the trunk on the right side; but the result showed that the force was sufficient to produce fatal internal injury.

Thus, after any accident involving external violence, the parts within may be far more seriously injured than the slighter hurt of the outside skin would indicate; and the possibility of such injuries is always to be kept in mind.

Of the several tissues of the body, each, according to its physical properties, has its peculiar mode of behavior under injury: thus, the arterial tissues invariably retract when cut across; and when arteries have been dragged upon, as in lacerated wounds, their internal tunics are torn across transversely, while the tougher outside fibrous coat of the artery retains its integrity.

Muscle contracts and retracts promptly when *cut* across, but hangs limp, from overstretching, when *torn.*

Nerves and tendons, through lack of shrinking capacity, tend always to project from a wound.

The skin especially, with its felting of mingled elastic and inelastic fibers, always when cut retracts more or less, and curls at its edges either inward or outward, so that in amputations and in the removal of tumors the surgeon must always allow judiciously for its shrinkage. When the skin has been habitually stretched as by a tumor, its contractile quality becomes impaired, and it contracts but little and very slowly after removal of the tumor. In the case of an enormous sarcomatous tumor of the testicle which was removed at the New York Hospital, elliptical incisions in the scrotum were made, including a liberal portion of skin so as to allow sufficiently, as was supposed, for loss of contractility in the atonied dartos muscle; but

the redundancy proved so great after removal of the tumor that it was judged wiser to cut away an additional portion of skin in order to prevent possible sloughing.

A more common and serious error consists in not leaving sufficiently liberal flaps in amputation easily to cover the face of the stump, thus creating tension which is a frequent cause of inflammation. It is preferable, when in doubt, to err in too great liberality rather than to risk a necessity for reamputation.

The skin also, in consequence of its abundant nervous supply as the seat of the sense of touch, is extremely sensitive, and it resents the tension of sutures and the contact of irritating dressings.

CHAPTER II.

Classification of wounds—Incised wounds—Their treatment.

For systematic study, wounds are divided into six classes: 1, *incised wounds*, those made by sharp-cutting instruments; 2, *punctured and penetrating* wounds, made by pointed instruments; 3, *lacerated* wounds, in which the tissues are subjected to traction before the solution of continuity is effected; 4, *contused* wounds, in which the tissues are crushed and divided by hard and blunt surfaces; 5, *poisoned* wounds, in which some substance possessing the nature of a poison is inserted into the tissues at the time the wound is inflicted; 6, *gunshot* wounds, produced by a projectile discharged from a firearm.

Most surgical lesions present more than one of the characteristic features set forth in this classification, and are, therefore, mixed in their nature. This is especially true of gunshot wounds, which partake in some degree of them all, including burns. But, for prompt recognition of the probable pathological consequences of a wound and the correct indications for its treatment, it is useful to keep these cardinal characteristics in mind.

For practical purposes, wounds are also classified according to the region of the body involved, as *wounds of the head*, *wounds of the chest*, *wounds of the abdomen, etc.*

Incised wounds affect the surface of the body and, for the most part, its soft tissues; although cutting and sawing of bone comes under this head. They are in-

flicted by a knife, razor, scissors, saber, cutlass or bowie-knife, or by a fine saw, especially if moved rapidly, as by machinery. All cutting instruments act on the principle of the saw, as may be readily demonstrated by bringing a magnifying power to bear upon the edge of a razor.

There is an infinitesimal amount of laceration attending a cut by the keenest knife and of contusion by the sharpest scissors, and, undoubtedly, microscopic particles of tissue killed in this way are left upon the edges of the cleanest cut; but these particles are so minute as to liquefy and dissolve promptly, so as to escape with the serous oozing that follows every wound, so that, usually, they offer no appreciable impediment to the process of healing. The knife of the surgeon produces the type of the incised wound, and, because its limits and subsequent conditions are more immediately under his observation and control, the phenomena presented by wounds of this class are more familiar to us and better understood. Those phenomena especially which attend the process of healing have been for obvious reasons very closely watched in incised wounds, and it is here that we can study them to the best advantage. By learning the several steps by which Nature heals simple wounds we can apply our knowledge hereafter to those of more complicated character.

The characteristic features of every incised wound are *pain*, *gaping of its edges*, *and bleeding*. It will be profitable to notice each of these in passing.

With *pain* the surgeon is necessarily very familiar. Its degree, in proportion to the extent of the hurt and its effects, varies greatly in different individuals; and the degree of courage with which it is endured is equally variable. Pain is more dreaded under many circumstances than mutilation, or even than death itself. It is a surgeon's duty too often to inflict pain. Happily, the advance of knowledge has brought in our generation great amelioration of this most serious evil in

the discovery of pain-killing drugs, or anæsthetics, by which it may be safely abolished. Surgery is therefore no longer the bugbear that it was in former days, especially in the eyes of the ignorant, to whom the dread of the surgeon's remedies was even greater than that of the consequences of the wound. The discovery of anæsthetics, and of the fact that they can be safely applied in the performance of operations, which is an achievement of American surgery, has added vastly to our power of preventing as well as of relieving pain; and in a like proportion it has magnified the usefulness and the greatness of our calling. It has brought a much larger share of the surgical necessities of humanity within the reach of our healing power; it has enabled us to undertake operations for their relief under circumstances of greater advantage; and, while it has thus increased our ability to do good to our fellow-creatures, it has vastly increased our responsibility.

The *pain* of an ordinary cut is due to the stretching and tearing of the sensitive nervous filaments with which the skin, as the seat of the sense of touch, is so abundantly supplied. Division by the knife of the other tissues of the body (the nervous trunks themselves excepted) is not nearly so painful as cutting the skin; although, under exceptional circumstances—as when inflamed—the more lowly organized tissues, such as tendon, periosteum, and bone—as of the teeth—are sometimes exquisitely sensitive, and it has not been satisfactorily explained why this is so.

Certain parts of the body are notoriously more sensitive than others—e. g., the lips, the flexor aspects of the hands and feet, the genitals, and the anus. On the other hand, the os and cervix uteri are especially insensitive to pain. I have seen the gas cautery liberally and persistently applied to an epithelial cancer of the mouth of the womb until it was reduced to an eschar without exciting any serious complaint.

In individuals, the gouty, the pampered, the hysteri-

cal, are for the most part over-sensitive to pain, or, according to more recent phraseology, *hyperæsthetic.* Men are sometimes met with who are exceptionally insensible to pain. I remember seeing such an instance at Velpeau's clinic, in a man who underwent the amputation of a finger for an ulcerated enchondroma without any complaint, protesting, apparently without bravado, that he felt no pain whatever, although the operation was performed in the most deliberate manner to establish the fact. Hysterical women sometimes present patches of insensible skin which may be pinched, cut, or pricked with needles without complaint.

The effect of severe pain upon the nervous centers is directly depressing to the vitality, and it is the surgeon's duty to prevent it whenever it is possible and proper. He who nerves himself to bear pain without complaint will suffer more exhaustion afterward than the one who makes an outcry. Extreme pain may cause fainting or collapse from shock, but rarely, if ever, actual death, as a direct result from this cause alone.

The surgeon soon learns to distinguish the degree and quality of pain, how far its expression is assumed through fear and anticipation or due to the desire to prevent further hurt, and to what extent it is real; but we must never lose sight of the varying susceptibility of individuals, and whenever there is any doubt the patient should have the benefit of it.

The first sensation of pain felt from the stroke of a knife is indescribable; it is most exquisite when inflicted slowly and upon an inflamed part, as in "lancing" a boil or in drawing a tender tooth. Afterward it is aching, burning, tingling, smarting; possibly only itching, for itching is a variety of pain; and it soon subsides into a sensation of numbness or stiffness. The pain of an incision is less when it is made from within outward; it is also less when made rapidly and when

it is unexpected. This is true of all wounds. A soldier may be struck in the heat of action and not recognize that he has been wounded until he sinks to the ground through loss of blood. Absence of mental occupation and of external sources of distraction explain why pain is harder to bear at night than during the day. The worst form of pain comes from pressure upon the larger nervous trunks, as by a tumor, or by an abdominal aneurism, or from disease in the nerve itself, as in facial neuralgia or *tic douloureux*.

We should never lose sight of the fact that pain has always a meaning or significance; it is in most instances a *signal of distress*, which it is the surgeon's duty to interpret and his privilege to relieve. He should not lightly give it the unmeaning name of "neuralgia," or attribute it to hysterical or gouty over-sensibility, certainly not until after he has failed, after careful scrutiny, to discover any other cause for it.

There is often, after a wound or a surgical operation, a degree of nervous excitability and loss of self-control on the part of the patient produced by continued or excessive pain, and sometimes amounting to delirium; in fact, this peculiar condition was first formally described by Dupuytren fifty years ago under the name of "traumatic delirium." Since the use of anæsthetics in surgery it is met with less frequently. It is not a dangerous condition, and opium is its best remedy.

The amount of *gaping*, or separation, of the edges of an incised wound depends upon the amount of yellow elastic tissue and unstriped muscular fiber in the integument of the part, and it also depends upon the direction of the incision—whether it is across *muscular* fibers lying immediately beneath the skin, or parallel with them. Wounds of the forehead and brow involving the fibers of the *corrugator supercilii* or of the *occipitalis* muscle gape excessively, and require sutures to keep their edges in contact and to prevent unsightly cicatrices. Previous over-stretching of the integument

diminishes gaping and retraction, as is seen in amputation after a limb has been torn off by machinery, or after the removal of a large subcutaneous tumor.

If a sharp-pointed, conical, or spindle-shaped weapon be driven through the skin, it will leave a perfectly straight, linear wound, hardly distinguishable from an incision; but the edges of this wound do not retract as if it had been made by a knife; they will lie almost in contact, limp, and inverted or everted, presenting the appearance sometimes seen in the wound of entrance made by a bullet. Here the elasticity of the fibrous structure of the skin has been temporarily abolished by the overstretching; and, besides this, the felting of its fibers has been at the same time unraveled, as in the skin of the abdomen of a woman from pregnancy. Club wounds of the scalp are often perfectly linear, like the wounds of the brow in children from falls, but their edges are retracted. On the other hand, after incisions through tendinous aponeuroses and non-retractile tissues like fascia, and after longitudinal incisions of muscles in the direction of their fibers, the edges of the wound often remain in such close contact as to prevent the escape of discharges which may collect within, and in wounds of this sort there is often a necessity for enlargement of the opening. This often happens in penetrating and gunshot wounds, and adds greatly to their danger, for the retention of discharges in a wound is a fertile source of evil by retarding the progress of repair, and the natural gaping of most wounds prevents this. In like manner, when the surgeon closes a wound artificially in the hope of securing more prompt healing, he often defeats his object by preventing the escape of retained fluids unless means are provided for artificial drainage.

The unequal retraction of the different tissues of a limb is a subject of more or less anxiety to the surgeon in amputations; the nerves and tendons project from the wounds, while the muscles and arteries for the most

part retract; and, if he does not make what seems at first an exuberant allowance of skin, the latter may, and often does, slowly shrink during the healing of the wound, so as to leave a rigid bone projecting at the summit of a so-called conical stump.

But the most striking feature of an incised wound is the gush of blood that follows the stroke of the knife. This we witness constantly in surgical operations, and, unless he is thoroughly familiar with its sources and causes and probable behavior, and thoroughly confident of his power to stop it at will, the suddenness of the gush is liable to disturb the self-command of the operator.

There is no subject in surgery of more urgent importance than hæmorrhage and its treatment, and I shall therefore give it, shortly, full consideration.

Meanwhile we have to speak of the *treatment* of incised wounds. Here the surgeon's duty is clearly comprised under these three indications: 1. To arrest bleeding; 2. To remove foreign substances, the presence of which may prevent union; 3. To bring the raw surfaces into accurate apposition, and to maintain them in quiet contact.

These indications, with certain exceptions incidental to each, are applicable to all wounds.

Under the *first* indication the means of arresting bleeding will be separately studied under the head of hæmorrhage.

The *second indication*, the removal of foreign bodies, is best fulfilled by removing carefully the larger extraneous substances with forceps, and the smaller by a stream of tepid water from a sponge or syringe. Incised wounds are less liable to require cleaning than the other varieties. The scrupulous cleaning of the surfaces of all wounds is a surgical necessity. I have seen a contused and lacerated scalp wound from a fall upon the head on the street-stones, with mud and dirt so ground into the raw surfaces as to be difficult of re-

moval; and yet this duty must be carefully performed, or prompt union will fail and suppuration follow. Gooch, an English surgeon of the last century, relates a case of a man gored by a bull at a country fair, whose intestines protruded. He was placed in a cart on some straw and taken some miles to a London hospital, where fragments of straw and other foreign material were carefully picked off the exposed intestines, which were then bathed with warm water and returned, and the wound accurately closed. This man, Gooch declares, got entirely well.

There are other similar cases on record. They should teach us never to neglect the most thorough precautions in treatment, no matter how desperate may be the character of the wound.

The ends of silk ligatures employed in tying arteries in wounds are foreign bodies. Heretofore it has been difficult, in fact impossible, to get rid of them; and their presence in wounds has been undoubtedly an obstacle to complete primary or quick union, and a constant cause of suppuration and danger. There is a good prospect at present of substituting prepared catgut, which dissolves in the wound-fluids, for silk.

The dust, also, which is always present in the air and liable to settle upon exposed raw surfaces, and which, especially in crowded hospitals, contains the germs of microscopic vegetable organisms of the class of fungi, or mold, must be included under the denomination of foreign bodies, and this can not be removed by ordinary means. These microscopic germs have been proved to be capable of contaminating our tissues and of gaining access to the blood. They find in wound-fluids and blood materials for support, and certain of them grow and multiply rapidly and infinitely, causing fatal forms of disease.

Modern science has taught us how to get rid of these foreign bodies by means both novel and, when properly employed, effectual. There are substances furnished us

by chemistry which are fatal to these microscopic organisms, and which at the same time are not harmful to our tissues, and the use of these substances in surgical dressings has added immensely to our power of treating wounds successfully. Most balsamic substances possess this valuable quality of destroying the vitality of the lower forms of organic life, and this explains why balsam of Peru and the other preparations containing gum benzoin are so popular as applications for fresh wounds. I may mention among the substances possessing this quality Turlington's balsam, Friar's balsam, cold cream, and the various hospital cerates. The addition of gum benzoin to cerates and ointments protects them from becoming rancid, in consequence of possessing this curious quality of preventing fermentation. Fermentation and putrefaction—which is also a fermentative process—are always caused by the presence and proliferation of these microscopic vegetable organisms. Hence the destruction of the vitality of these organic germs not only prevents ointments from becoming rancid—which is a variety of putrefaction—but it arrests and prevents the putrefactive process under all circumstances. The word *septic* is synonymous with *putrefactive;* hence substances which possess this property are called *antiseptic;* they are also called *germicides.* Vaseline belongs to the class of antiseptics.

The typical germicide, and that which is at the present time in most general use, is *carbolic acid*—heretofore employed as one of the constituent ingredients of the more familiar creosote, a drug long known for its anti-putrefactive properties. An especially valuable quality of carbolic acid is its volatility, which renders it more widely applicable than the *boracic* and *salicylic* acids, which are otherwise equally antiseptic. A two- to five-per-cent solution, in water, of carbolic acid is employed with great advantage in washing or syringing out recent wounds, and it is also used in the form of spray, the carbolic solution being pulverized or atom-

ized by machines contrived for this purpose, of which there are many varieties in use.

The *third indication* in the treatment of wounds—i. e., to keep raw surfaces in accurate apposition and at rest, with a view to prompt healing—may be accomplished by a number of different contrivances which experience has accumulated. Among those most constantly in use are *plasters*—of lead, isinglass, and collodion; *sutures* in many varieties—of silk, catgut, metallic wire, horse-hair, metallic pins, needles, and clamps; *elastic pads* of wool or cotton, with *splints* and *bandages* of every kind by means of which immobility can be secured. All these contrivances and the various modes of applying them will be described hereafter and shown in the demonstrative and clinical lectures.

CHAPTER III.

Hæmorrhage—Varieties—Spontaneous Arrest.

WHAT is understood by the term hæmorrhage?

It is simply the escape of blood from the blood-vessels.

In wounds, and under ordinary circumstances, the blood in hæmorrhage escapes through a breach of continuity in the walls of the blood-vessels. But there are rarer forms of disease which may be mentioned in which there is an oozing through the walls of the more minute blood-vessels, the capillaries. Thus, in the morbid condition known as *purpura hæmorrhagica*, there is bloody expectoration and bloody urine without any lesion of continuity of the blood-vessels. In a case of that very rare affection called *hæmatidrosis* or bloody sweat, which occurred in the adjoining hospital, I saturated a white handkerchief with the red oozing from the forehead in less than half an hour. This latter, I may say, is a nervous affection occurring in hysterical young women from intense congestion of the capillary plexus of vessels in which each sweat-gland is imbedded, through morbid action of the vaso-motor nerves.

The gush of blood that follows the first stroke of the knife in a surgical operation is of a maroon or garnet color. It is furnished by capillaries, veins, and the smaller arterial branches or arterioles, their contents as poured out being mingled in varying proportions. The color of the blood that escapes from the capillaries and veins is dark; that from divided arteries is bright scar-

let. The blood from the former escapes with a gush, like water squeezed from a sponge; arterial blood spins out from isolated points in fine streams, generally thrown to some little distance, with a distinctly intermittent impulse derived from the contraction of the left ventricle of the heart.

When a larger artery is wounded, its blood escapes with a distinctly hissing sound, and the jet, which is thrown *per saltum*, or by a leap, shows still more manifestly the impulse of the heart. If pressure be made by a finger or otherwise upon the parent trunk from which the wounded branch is given off, the arterial jet is at once controlled.

It is important that the surgeon should be able to recognize promptly the escape of *arterial blood*, and to estimate its amount; and the peculiarities of arterial hæmorrhage I have just enumerated furnish the best evidence on these points. The scarlet color of the blood, its *per saltum* impulse, and the fact that its escape is controllable by pressure applied upon the nearest supplying trunk between the wound and the heart, are infallible indications of its arterial source. By stopping the flow momentarily and then allowing it to recommence, the amount of blood that is being lost can be fairly estimated.

The escape of *venous* blood from a wound, as, for example, from the face of a stump after amputation, is *not* controlled by pressure applied upon the main vessels of the limb; it is, on the contrary, increased, because the return of the venous flow toward the heart is thereby impeded, and it is forced to escape in larger amount from the surface of the wound. It is for this reason that the surgeon, after promptly seeking out and tying the larger arteries which he knows require a ligature, should at once remove the tourniquet, which, by constricting the whole limb, tends to keep up the escape of blood from the veins.

It is proper here to call your attention to the fact

that when a patient is inhaling ether for anæsthesia his arterial blood is thereby rendered darker in color—often as dark as that from the veins; so that its scarlet color no longer serves to distinguish the arterial flow. The ether vapor takes the place of air in the lungs, and the temporary lack of oxygen deprives the blood returning to the left auricle of its usual scarlet tint. This curious fact has not been found to cause any serious trouble in practice.

Where no artery of size has been divided, the first gush of blood from an incision, although free, and sometimes for the moment startling, immediately subsides. It continues to lessen, and, if there is no obstruction to the veins between the wound and the heart, and none of the smaller arteries require tying or twisting, within five minutes—more or less, according to the size of the wound—it ceases entirely, and gives place to a watery oozing. Now, this is a phenomenon which I desire especially that you should recognize—viz., *the tendency to spontaneous cessation of hæmorrhage*, unless it is kept up by obvious causes. It is a conservative tendency, and can always be relied upon by the surgeon.

The only exception to this rule is where that rare and curious condition known as the *hæmorrhagic diathesis* is present. The essential feature of this affection is a congenitally abnormal quality of blood which renders it inapt to coagulate, whereby its victims are liable to bleed obstinately from slight causes. Its pathology is not accurately known.

It will be profitable, I think, if we should seek an explanation of this natural phenomenon, *that within certain conditions traumatic hæmorrhage always tends to cease spontaneously*. The explanation is not difficult to find. Experiments upon animals and observation in human surgery have demonstrated that it is due, *first, to the tendency of the tissues to contract and retract themselves when exposed to the air; and, second, to the property of coagulability of the blood.*

I need hardly remind you that there is a much larger proportion of unstriped or organic muscular fiber in the walls of the smaller than of the larger arteries of the body; that, in fact, this anatomical element increases in quantity in proportion as the arteries diminish in caliber. This is so true that when an arteriole is cut across transversely it contracts and puckers in so thoroughly as to cease very soon to give blood. There is not only pretty tight contraction of the cut end, but the vessel also shortens itself and retracts within the envelope of connective tissue in which every artery is imbedded. Thus, there is not only *con*traction of the caliber of an artery as soon as it is cut across, but also *re*traction of the cut end within its sheath. These phenomena invariably take place in all arteries when divided, but more noticeably and effectively in the smaller vessels.

The lower temperature to which the *unstriped* muscular tissue is exposed in a wound intensifies its contractile tendency for the same reason that exposure to cold air makes the scrotum contract.

Again, the property of *coagulability of the blood*, with which your physiology has made you familiar, is the other important factor by which the spontaneous cessation of hæmorrhage is to be explained. Coagulation always takes place immediately when the escaped blood is at rest. Thus, a divided artery as large as a digital branch of one of the palmar arches, or even of the trunk of the ulnar, retracting within its sheath and still pouring out a diminished stream, injecting the meshes of the surrounding web of connective tissue, soon becomes entirely obstructed by the plug-like barrier which results from the rapidly forming coagulum. And the coagulation is hastened by the contact of the blood with the delicate fibers of the tissue into which it is injected. So that, in less time than it has taken me to describe the process, the arterial flow will have ceased entirely.

All arteries of the size of the ulnar, and below it, may be trusted to stop giving blood under the influence of these causes alone, ordinarily; but it is the habitual practice of the best operating surgeons not to rely entirely upon this *natural hæmostatic effort*, and, as a rule, before finally closing a wound, to place a ligature upon every vessel that can be made to yield blood.

To make vessels bleed after they have already ceased, it is the practice to scratch away with the finger-nail all points at which a coagulum has formed upon the wound's surface. If fresh blood can in this manner be made to flow continuously, in ever so small quantity, the ligature is applied; if not, it may be assumed that Nature's remedies have firmly sealed the divided vessel.

This practice is justified by the possibility that the increased action of the heart that accompanies subsequent reaction or possible fever may, and not infrequently does, start an artery bleeding again after it has been apparently closed by Nature's hæmostatics. When an artery thus begins to bleed again, after an interval of apparent closure, it constitutes one of the forms of what is called *secondary hæmorrhage; and secondary hæmorrhage is always a source of trouble, and often of danger.*

A lady was once brought to me with a tumor of the orbit, which protruded the eyeball and interfered with vision. In undertaking its removal, in order to save the deformity of a scar, I shaved off the eyebrow and made an incision along the upper margin of the orbit, carefully avoiding the supra-orbital nerve, so that I might get access to its cavity and save the levator muscle of the upper lid. The tumor was found to involve the lachrymal gland, and the whole mass was readily removed. There was but trifling bleeding, and this soon ceased entirely. The eyeball was restored to its normal position, the wound carefully closed by sutures, and the patient was able to raise the upper lid. Late in the

evening I was summoned on account of very considerable swelling and tension at the seat of the operation, and, recognizing by the ecchymosis that bleeding had taken place in the wound, I proceeded to take out the sutures and reopen it. Quite a mass of coagulum was turned out, but, after a most careful search, I was unable to find any bleeding vessel. Nature, under the counter-pressure of the effused blood, had sealed it again, and this time permanently, for, after closing the wound again in the same manner as at first, there was no return of bleeding; but to my mortification I found, when the dressings were finally removed, that my patient had lost the power of raising the upper eyelid. The hæmorrhagic distention had ruptured the nerve supplying the *levator-palpebræ* muscle, perhaps the muscle itself.

Secondary hæmorrhage may occur in other ways and by a different mechanism; as when the walls of an artery fail to grow together in a solid manner under the action of the ligature, and ulceration follows, permitting escape of blood, which, when the artery is large, is often fatal.

We may assume, then, that *Nature's resources for controlling arterial bleeding are contraction and retraction of the cut vessels, and coagulation of the blood.* For vessels below a certain size they are generally efficient; when larger arteries are wounded, they only delay a fatal result and afford more time for action. Often, as in hæmorrhage the source of which is concealed—*internal hæmorrhage*, for example, as where there has been a slight laceration of the liver, or a wound of the lung-substance or of the kidney—these natural hæmostatics constitute our main reliance, and they are not infrequently competent to avert a fatal issue. We often detect cicatrices in these organs in the dead-house.

It is very desirable, therefore, that the surgeon should be able to favor the action of these natural

hæmostatics, that he should have a clear idea as to what helps and what retards it.

When a man is wounded in the lungs, as by a bullet or a knife-thrust, the immediate danger is from suffocation by escape of blood from wounded vessels into the lung-tissue; presently he faints, through loss of blood. When he recovers from the syncope the escape of blood into the lung-substance is found to have ceased; and, possibly, if the patient is kept absolutely quiet and without motion, it may not recur, and recovery may follow without further aid than that which Nature has afforded. Here the cessation of the hæmorrhage has been due to the contraction and retraction of the wounded vessels and the coagulation of the blood; and *this mechanism has been greatly aided by the slowing of the heart's action during the syncope, and the consequent weakening of the force of the arterial jet.*

We may properly pause here to answer the question, What is this condition of *syncope* or fainting which is thus competent to aid the surgeon in the control of hæmorrhage?

In syncope the sudden loss of blood has deprived the brain of its necessary blood supply, and the functions of the great nervous center are consequently interrupted and *almost* suspended; the fainting patient sinks to the ground pallid and insensible. With the suspension of nerve-supply to the heart, as well as to the other muscles, the function of the great center of circulation is also suspended, *but not absolutely and entirely.* In what is called a dead faint, the finger on the radial artery may not be able to distinguish any pulsations, but the ear, applied over the region of the heart, discovers that there is still a rhythmical flutter, and that the breathing, although faint and shallow, is still regular. You have here the phenomena of syncope, and also the means of distinguishing real death from syncope, which so closely resembles it.

When a patient faints from some other cause than loss of blood—e. g., from mental emotion, which is entirely possible, or some comparatively trifling cause, such as lancing a gum-boil, or the first introduction of a catheter—if you proceed to elevate the lower limbs and let the head hang in a depending position you can almost see the blood flow back to the brain; the pallor leaves the face and lips, and the pulse and intelligence return at once.

It is thus demonstrated that *the symptoms of syncope or fainting, whether from sudden loss of blood or other cause, are due to temporary lack of blood in the brain and coincident failure of the heart's action.* The initial symptom may be the faltering of the heart; but, where there is no sudden loss of blood to affect the heart first, it is obvious that the center of sensation must be primarily influenced, and that the heart feels the secondarily inhibitive effect. In either case you see that the slowing of the heart's action and the lessened force of its contractions tend to diminish or suspend arterial flow, and thus to favor coagulation of blood, by which the wounded artery may be forthwith closed, as with a plug.

It is evident, therefore, that *syncope* is a notable factor, in truth a great and positive aid, in Nature's hæmostatics. You are to recognize that it is not necessarily dangerous to life, although its appearance is usually alarming to the ignorant; and also that it may be decidedly advantageous, under some circumstances, to favor its continuance. You may go even farther than this and even take measures to produce syncope to aid in controlling internal hæmorrhage; it is recommended by high authority in case of threatened death from wound of the lung to have the patient held in the upright position and to bleed him from the arm, or even from both arms at the same time, until he faints. You see now how this extreme and apparently desperate measure may save life. I will shortly dis-

cuss the mode of death by hæmorrhage, and you will learn how much blood may be lost without an immediately fatal result, and be able in such a crisis to act intelligently. For the present you may receive the fact that syncope is a valuable adjuvant in securing the arrest of hæmorrhage by Nature's hæmostatics, and with this the assurance that we may help Nature in desperate cases by promoting the tendency to faint.

It is evident that the result secured by syncope is effected by securing temporary arrest of motion at the bleeding point—*by keeping things still for a few minutes*—and thus favoring coagulation of the effused blood.

If the heart's action is too suddenly revived by means that favor the flow of blood to the brain, such as friction or stimulants, the plug of coagulum just formed may be washed away from the orifice of the divided artery and the hæmorrhage started afresh. A continuance of the state of quiescence produced by fainting is therefore to be desired in order to secure its full effect, and to accomplish the permanent arrest of internal hæmorrhage, as far as this is possible. Remember, therefore, if you please, that rest, *absolute rest*, is another most valuable adjuvant to Nature's hæmostatics.

From the reports of agents of the Sanitary Commission and the records of the Army Medical Department, I have knowledge of instances in which soldiers wounded on the field of battle, when lifted into ambulances and jolted away to field hospitals, have had internal bleeding renewed, and men have died in consequence of this mistaken kindness who would probably have survived if left alone and kept in a state of absolute quiescence.

It is mainly by its influence in promoting rest and quiescence that *opium* has attained the reputation it enjoys as a remedy for hæmorrhage; and there are some other drugs to which the same quality is attributed with more or less truth. Thus the preparations of

lead are sedative and astringent, and the *acetate* is often administered in passive hæmorrhage in combination with opium. The *mineral acids* have the same reputation, especially the *sulphuric*. *Ergot* possesses undoubted power as a hæmostatic; it acts by stimulating the contractility of the unstriped muscular fiber in the minute arteries, and thus contracting their caliber. The *veratrum viride* has also a certain power of controlling the heart's action, and is employed for this purpose. I have enumerated these drugs as aids to nature's hæmostatic powers, because they have their value in certain conditions of the system in which the surgical remedies for hæmorrhage are inapplicable, as, for example, for internal bleeding; and where the persistence of hæmorrhage may be due to disease—as in Bright's kidney, or the epistaxis of alcoholism.

The preparations of iron, although of great value when taken internally in renewing the blood, and as astringents when applied externally—the subsulphate, for example—possess no specific value.

These remedies are properly mentioned in connection with the natural tendency to the cessation of hæmorrhage which they assist and favor; and *they should retain this connection in the mind of the surgeon as distinct from the surgical remedies for hæmorrhage which we are about to consider.*

It is as well that I should call your attention to the fact that in the present state of our science there is no form of hæmorrhage which is properly regarded as a disease; it is a symptom, merely, of some already existing morbid condition of the organism; for us, at present, it is the symptom of a surgical lesion. Thus, *epistaxis, or bleeding from the nose*, which the surgeon is often called to remedy, is not a disease, but a symptom of disease of the heart, of Bright's disease, of a local congestion from some other cause, which congestion is relieving itself. *Hæmaturia, or bleeding from the urinary passages*, is a symptom of calculus, cancer,

enlarged prostate, or poisoning from turpentine. The *bleeding from the gums in scurvy* is due to the want of certain elements in the blood through defective selection of food.

Hence, many of the terms employed by the older authorities to designate varieties of hæmorrhage, when it was described as a disease, have for us lost their significance: such as the terms "active," "passive," "critical," etc. The hæmorrhage from the bowels in typhoid fever, regarded for centuries after Hippocrates as a "critical discharge," is now recognized as a symptom of intestinal ulceration.

The only terms at present applied to hæmorrhages are those which indicate their origin, and which serve at the same time to designate the two classes into which they naturally divide themselves, viz.: *traumatic*, those caused by wounds; and *symptomatic*, those due to disease.

Traumatic hæmorrhages are also spoken of as *primary*, when they follow immediately after a wound; and as *secondary*, or *consecutive*, when they occur at any subsequent period before its final closure.

In defining *secondary hæmorrhage it is necessary to be more critical.* If a wound, the result, for example, of an amputation, be closed too soon, as I have known to happen in the operating-theatre, it might continue to ooze after the patient has been carried to his bed in the ward; or it might begin to bleed, as the normal reaction from the shock of the operation takes place, from vessels which may not have closed themselves sufficiently to resist the increasing force of the heart's action under the influence of reaction combined with the effect of the warmth of the bed, and of the dressings; or bleeding sometimes results from the effect of the stimulants administered at the time of the operation; or from the restlessness and agitation that sometimes accompany the subsidence of the anæsthesia. Resulting from any of these causes, there is complaint,

in an hour or two after an amputation, of pain in the stump calling for examination, and it becomes apparent that there is hæmorrhage which demands interference. This necessitates removal of the dressings and reopening the wound; it may be necessary to reapply the tourniquet and readminister the ether before the source of the bleeding is found and the vessel secured.

Now this is not technically called secondary hæmorrhage; it is nothing more than primary hæmorrhage, which nature and art have failed to permanently staunch. At one time, I have been told, this sort of hæmorrhage, through some defective method of dressing wounds, was so common in one of the London hospitals that the term "intermediary hæmorrhage" was employed by the late Sir William Ferguson to describe it.

But when a wound has been deliberately and properly cared for at the time of operation, and left open for some little time afterward, or until full reaction has taken place—*and this may be done without lessening the chances of obtaining prompt union*—this complication seldom occurs. It was the habit at one time at the New York Hospital to leave the wound after amputation, or the removal of a tumor, to be dressed by the house surgeon, either in the operating-theatre or in the ward; and under this mode of management subsequent hæmorrhage was very rare.

The term *secondary hæmorrhage is strictly applicable, therefore, to those cases only in which bleeding comes on after the process of repair has fairly commenced in a wound, and during its progress.* When not provoked by actual renewal of traumatic injury, as by rough handling or accidental bruising, it is due to some defect or failure in the process of repair, the cause of which is to be sought for; it may be failure in healing through lack of vitality, or even actual sloughing, the dissolution, by suppuration, of an organizing coagulum which had plugged the mouth of an

artery, or, in a case of gun-shot wound, the separation of an eschar. The term secondary hæmorrhage is also applied to bleeding from an artery which has been treated by ligature for aneurism, and where the process of obliteration of the vessel, for any cause, has failed.

In considering the phenomena which attend bleeding from a wound, we notice that, in addition to the variation in the hæmorrhagic flow as regards color, amount, force, etc., according to the size and location of the wound, there may be an admixture of other substances with the blood—as of pus, glandular secretions, or the contents of internal cavities, as of the intestines. Thus, the blood escaping from a stab in the loins might contain urine—recognizable by its odor—if the kidney were wounded; or, in a suicidal wound involving the trachea, the effused blood would present a frothy appearance from admixture of mucus and air from the lungs.

Again, there are certain localities in the body in which, from their greater vascularity, or from the laxity of the connective tissue, capillary and venous oozing, or bleeding from the smaller arterioles, is not as readily and promptly controlled by nature's conservative forces as I have led you to anticipate. For example, in wounds of the spongy or erectile tissue of the genitals—as of the *corpus spongiosum urethræ* after the internal division of a stricture—the flow is liable to persist unpleasantly, although no large vessel has been divided. This occurs also in wounds and operations on the female genitals. A man was tried for his life in England because his wife bled to death from a kick which he had given her in the vulva. Operations upon the tonsils and pharynx, even when trivial, sometimes bleed unpleasantly. The arrest of capillary oozing, which in health never fails to take place spontaneously, is due, as I have said, to the contractility of the tissue in which the capillary network is imbedded. The meshes formed by the capillaries of mucous mem-

brane are larger, and the connective tissue by which they are surrounded is more scanty and more loosely distributed—less closely felted—than in the skin, and this accounts for the greater freedom and persistence of capillary oozing in wounds of the mucous membrane, and in some degree for the more frequent occurrence of systematic hæmorrhage from these surfaces, as in habitual bleeding from the nose.

There are few practitioners who have not encountered instances of obstinate oozing from trivial wounds of the throat, rectum, urethra, or vagina. Billroth relates a case in which, after an insignificant operation on the throat, a patient was treated by several physicians for vomiting of blood which recurred obstinately, and the patient's life was only saved finally by an experienced surgeon, who discovered that the little wound in the throat was still persistently oozing, and that the blood had been unconsciously swallowed and, at certain intervals, vomited from the stomach.

As I have already intimated, this persistent oozing, formerly called "passive hæmorrhage," is often kept up by a poisoned condition of the blood which prevents it from coagulating, or from sealing up the wound by plastic exudation—as from Bright's disease, or from alcoholism. I was once sent for by my colleague, Professor McCready, to see a gentleman who had been bleeding for nearly a week from the socket of a recently extracted molar tooth. He had a sallow and waxy complexion, his breath had a distinctly urinous odor, and his urine was found to contain albumen, and also tube-casts from the kidney in large numbers.

In another case of obstinate epistaxis in a liquor dealer who was an habitually hard drinker it was found necessary to plug the nostrils with sponge behind and in front in order to prevent serious consequences. I have seen similar results in the way of bleeding follow wounds of the rectum involving the hæmorrhoidal plexus, as after an operation for fistula or piles, where,

in the absence of all outward signs of hæmorrhage, the patient began to sigh and perspire and complain of faintness, and presently, yielding to a desire to go to stool, passed an enormous collection of half-formed blood-clot from the bowel. It was in consequence of the frequent occurrence of hæmorrhage in this way, which in several cases ended fatally, that Dupuytren was forced to give up operating upon internal hæmorrhoids with the knife, a practice which at one time he strongly advocated.

The tendency of wounds in these localities to bleed is also promoted by the constant high temperature of the interior of the body. Warmth always tends to prevent coagulation. Cold, on the contrary, favors it. We promote the flow of blood from leech-bites by warm fomentation by which clots that have formed are washed away, and the formation of new clots prevented.

When *veins* are wounded, the color of the blood that escapes is dark, and its flow is feeble, slow, and continuous. Venous hæmorrhage tends to cease spontaneously: first, through the feeble force of its current; second, through the thinness of the walls of the veins which allows ready collapse from outside pressure; third, by the presence of valves which obstruct the venous current except in the direction of the heart. All these points are illustrated in the simple operation of blood-letting from the arm.

It is evident that pressure alone, and usually slight pressure, is the only remedy required to control *venous* hæmorrhage.

But there are exceptions to these ordinary features of venous bleeding; for example, where very large veins are wounded, especially the jugulars at the root of the neck, where the alternate rise and fall of the ribs in respiration causes corresponding collapse and distention. Here the flow from an opened vein is neither continuous nor moderate; it alternately ceases for an

instant and then gushes out copiously as from a fountain, and is accompanied by no little danger.

Another exception to the spontaneous cessation of venous hæmorrhage occurs where the walls of a large vein are adherent externally to unyielding tissues so that they can not collapse, where they are converted into unyielding canals like the hepatic veins and some of the sinuses of the brain. There are certain localities in the body in which this anatomical arrangement exists at a solitary point in the course of a large vein—evidently with the purpose of protecting it from outside pressure—as where the vena cava, as it passes upward to the right auricle, traverses the tendinous center of the diaphragm; or where the axillary vein, just about to become subclavian, is attached as it passes beneath it to the borders of the arch formed by the coraco-clavicular ligament. Here the vein when divided can not collapse, but remains necessarily gaping.

In this latter locality a redoubtable accident has occurred which is always liable to complicate wounds of large veins within a short distance from the base of the heart, where they are prevented in this manner from collapsing. I refer to the *suction of air into the vein*, as the ribs rise in the act of inspiration, and thence directly into the cavities of the heart. This accident is accompanied by a peculiar hissing sound at the moment, and followed by sudden and great distress in breathing, ending in some cases rapidly in convulsions and death. After death occurring in this way the cavities of the heart have been found full of bloody froth.

The late Valentine Mott had a case in which, while he was removing a tumor imbedded deeply in the axilla, the hissing sound was heard, and in an instant the patient rolled off the operating-table on to the floor in uncontrollable convulsions. After a time, however, they subsided, and the patient ultimately recovered.

The possibility of this accident should always be kept in mind during surgical operations in this locality

and at the root of the neck, where, in fact, it has happened in most instances. Prompt and effectual closure of the wound by pressure, and the administration of diffusible stimulants, are the surgeon's best resources if such an accident should occur.

Veins of smaller size are often found converted into canals with rigid walls, in parts which have long been the seat of inflammation, where the meshes of the connective tissue are solidly filled with exudation which has become organized, and where the knife cuts as through cartilage, showing the orifices of veins gaping, as seen on section of the substance of the liver, only smaller. We meet with this condition of the tissues in operations upon the perinæum, in cases where urinary fistulæ have long existed, and also in operating upon old fistulæ in ano. Under these circumstances the flow of venous blood that follows the incisions is at first greater than usual, and it shows less tendency to cease spontaneously, requiring occasionally some pressure to restrain it, but after this coagulation soon follows.

Thus, we find that while hæmorrhage from veins of small and moderate caliber is self-limiting, or yields readily to simple pressure, wounds of large veins may be the most formidable incidents of surgery.

I have thus far assumed, in speaking of bleeding from arteries, that the wound of the artery communicated more or less directly with the open air—the contact of which alone, mainly in consequence of its lower temperature, certainly tends to stop a hæmorrhagic flow. But suppose that the wounded artery lies at some depth, and that the vessel may have been only partially divided and opened by a punctured, penetrating, or gun-shot wound. Here different results follow, according to the circumstances of the arterial wound. In a longitudinal or slightly oblique wound of the walls of an artery there is but moderate retraction of its edges, and, after the escape of some blood which, collecting in the tissues in its immediate neighborhood,

begets a certain amount of pressure, the bleeding, if the wound of the artery be small, may be arrested permanently. A little button- or stud-shaped clot forms in the wound of the artery and occludes it, and may become organized and serve as a permanent bond of union between its edges. The internal portion of this little stud-shaped clot may not project far enough into the caliber of the artery to obstruct the flow of blood through it, so that the usual pulsation may be detected in the wounded artery beyond the wound, or, according to the expression usually employed, on the *distal* side of the wound. *It is well to know that arterial wounds of this simple character*, when of limited extent, may heal entirely without any interruption in the function of the vessel, even if of a large size; and probably such wounds have often passed unrecognized. But experience has shown that there is always danger, after such a lesion of the arterial walls, of subsequent stretching of the cicatrix under the force of the heart's impulse, and the formation of an aneurismal tumor at the seat of the wound.

A middle-aged man from the old country once presented himself at my clinic with a little spherical pulsating tumor, the size of a cherry, situated upon the anterior branch of the temporal artery just external to the brow. It had followed a lancet wound made some years before when he had occasion to be bled from this artery—a remedy formerly a good deal employed for head symptoms. The rule in this operation of arteriotomy is to open the artery by an oblique incision, and, when a sufficient quantity of blood has escaped, to reintroduce the point of the lancet and divide the vessel across transversely and completely, so that its ends can retract and obliterate themselves. This simple resource, with the aid of temporary pressure by a small compress and bandage around the head, has been found entirely sufficient in most cases to prevent further hæmorrhage. It became evident subsequently that in my

patient this complete transverse division had not been effected. He complained very much of the buzzing and throbbing in his temple, which interfered with his sleeping when his head lay upon the pillow, and he asked for relief. I therefore at once excised the little aneurism by two elliptical incisions and tied both ends of the artery in the wound, which was healed by the following week.

In laying open the excised tumor it was found that the little orifice by means of which its cavity communicated with the caliber of the artery was oblique in its direction, and that it evidently corresponded with the original incision of the vessel at the time of the bleeding. The cicatrix by which it had been originally closed had either given way by rupture, or had become distended so as to form, with the surrounding connective tissue, the walls of the little aneurism.

My colleague, Professor Wood, once cured a much larger aneurism of the femoral artery, which had a similar origin, by ligature of that vessel between the tumor and the heart. A boy, while whittling with a pen-knife, dropped the knife as he sat, and, involuntarily closing his thighs to catch it, the point of the blade penetrated his femoral artery. The bleeding was arrested at the time by pressure, but the subsequent formation of an aneurism was disclosed by the usual signs and cured by the Hunterian operation.

Hodgson, in his excellent monograph upon diseases of the arteries and veins, gives the case of a lady who, in a state of temporary depression, stabbed herself with a pen-knife in the neck below the angle of the jaw, wounding the carotid or one of its primary branches, and causing immediate and abundant hæmorrhage, which, during syncope, ceased and did not recur. Not many days afterward a growing pulsating tumor formed at the seat of the wound, and this was ultimately cured by ligature of the carotid at the middle of the neck.

But the bleeding from a deeply situated puncture of an artery may not cease so readily: infiltration of the tissues may go on outside of the sheath of the wounded vessel; it may extend to the *intermuscular* layers of connective tissue, and, under the continued forcible pumping action of the heart, may travel to a very considerable distance; and the wound in the artery failing to close while the external puncture of the integuments has become sealed, the impulse may be communicated to quite a large collection of extravasated blood, so as to prevent its entire coagulation, resulting thus in another form of false aneurism, i. e., a pulsating tumor containing blood and communicating with the caliber of an artery.

I have seen a stab with a knife in the arm just above the elbow produce a huge pulsating tumor, which involved the whole segment of the limb and extended as high as the axilla.

The tendency to bleed is greater in an artery which has been only partially divided, because, as in the old operation of arteriotomy which I have described, *in partial division there can be no retraction of the ends of the vessel.*

But the hæmorrhage from a wounded artery is most free and persistent when a piece has been taken completely out of the substance of its walls—as by a passing bullet, or, later, by the falling of an eschar; or by what is equivalent to this, where a small arterial branch given off at right angles has been cut off very close to its origin from a large parent trunk.

The eminent English surgeon, Liston, incurred much criticism some years ago for tying the external iliac artery in a gentleman wounded in a duel, in whom the bullet had traversed the front of the thigh just below the groin, causing the immediate formation of a large pulsating tumor. It was assumed that the femoral artery had been wounded very high up. The patient was in an unfavorable condition, and died after the

operation from peritonitis. On post-mortem dissection, it was found that one of the small external pudic branches given off from the front of the femoral had been cut off quite close to its origin—shaved off, as it were—and the main trunk was intact.

I was once summoned to a case of a somewhat similar character, in which I was obliged to apply ligatures to the primitive carotid artery. It is a good many years ago, but all the features of the case recur to me very vividly. A young surgeon had undertaken the removal of an enlarged gland from the neck of a young lady. It was situated over the carotid artery. It was dark when I arrived, and an assistant was beside the patient ready to make pressure if required; and I remember being struck by the extreme pallor of the girl, and by the amount of blood on the sheets upon which she lay. I recollect, also, being surprised by the account of the copiousness of the hæmorrhage, and also, as I removed them, by the number of rags which had been stuffed into the wound. Finally, as the last rag was carefully lifted, I caught sight of the bleeding-point as the gush came, and was able to control it by the point of a finger, pressing it against the transverse process of a vertebra. The case had been described to me as a wound of the carotid, and there seemed no reason to doubt it. The young woman had had already several fainting fits before I arrived, and the gush I had just seen was certainly free enough to confirm this opinion; so I proceeded to pick away very carefully with the forceps in my right hand, which was disengaged, at the sheath of the carotid, which was injected with blood, and, presently reaching the outer coat of the vessel, succeeded in insinuating the beak of an artery-needle beneath it, carrying a ligature in its eye. The same manœuvre was repeated below the point where the finger controlled the hæmorrhage, and, when both ligatures had been tied, and the finger—which by this time had become very numb—gradually withdrawn, I was able to satisfy

myself that the main trunk of the carotid had not been directly wounded, but that a branch, undoubtedly glandular, given off nearly transversely, had been cut across so close to its origin that it would not have held a ligature. The surgeon told me that the tumor extended more deeply than he at first supposed, and that when he got down near the carotid, fearing to dissect any farther, he drew the tumor out and severed its remaining attachments at one stroke; and then came the copious gush of blood—so full and free, and with a hissing sound, that he felt at once that he had wounded the carotid.

This patient made a good recovery.

I should like you to think over this case, and to draw certain inferences from it. First, that the removal of glandular tumors from the front of the neck is an operation never to be lightly undertaken. The lymphatics, and the chain of glands called the *glandulæ concatenatæ*, lie deeply in contact with the carotid vessels, and can not be removed without laying them bare. Their removal by operation is rarely a judicious measure for other reasons; their enlargement is usually the result of a scrofulous diathesis, and this should be treated preferably by constitutional remedies. Their removal is sought by young girls with the view of improving their personal appearance, a motive which alone hardly justifies the operation. In dissecting out such tumors, their final attachments should be always carefully surrounded by a ligature before being severed—the ligature being left in the wound. It is therefore an injudicious manœuvre to draw out a tumor and cut across its deepest attachments, for they are almost certain to include its principal artery. Finally, this case affords another proof of the fact that an arterial branch cut off close to its origin from a great trunk is likely to bleed as freely as though a piece had been cut out of the wall of the great trunk itself.

A wound of an artery the size of the primitive caro-

tid, subclavian, or external iliac, is usually fatal in a few minutes; but there are perhaps a score of cases on record in which the conservative forces of nature have preserved life after such an accident with little or no aid from art. The rule is, however, as I have stated. (It is illustrated in Lord Castlereagh's case of suicide.)

It is well for a surgeon to know how much blood may be lost from such a wound without causing death; and this, by the aid of certain data, we can approximate. According to Flint, the body contains about one twelfth its weight of blood. It has been estimated that the sudden loss of one half of this would be necessarily fatal. To put it differently: a man weighing one hundred and ninety-two pounds has about sixteen pounds of blood in him; if, therefore, he should lose eight pounds within a little time he would probably die. But if the blood were lost slowly, or at intervals, a larger total might be reached without a fatal result.

These statements are, of course, approximative, but they are not without practical interest. Popular estimates of the amount of blood lost are, as a rule, very much exaggerated.

The estimates I have given do not apply in childhood or old age, at both of which periods of life loss of blood is badly borne. I have known the blood lost by an infant in the operation for hare-lip to cause death by convulsions. In advanced age the blood is renewed so slowly that, even if death is not caused outright by a copious hæmorrhage, its subsequent effects are often fatal. As a rule, women bear loss of blood better than men.

Meanwhile it is very important that we should make ourselves familiar with the general symptoms and consequences of hæmorrhage, apart from syncope and the more obvious phenomena attending the local flow which have hitherto occupied our attention; for hæmorrhage is not infrequently *concealed*, going on within the recesses of the body and manifesting its effects

only through general symptoms. The physician witnesses these symptoms sometimes in women after delivery. As observed in a case of serious and persistent internal bleeding, they are as follows: Blanching of the surface of the body, and also of the mucous membranes, as seen on inspection of the tongue, mouth, and gullet; smallness and increasing frequency of the pulse—from the diminishing volume of blood in the heart and arteries; a feeling of weakness and languor, with indisposition to motion, which is not, on the whole, unpleasant; a tendency to deep sighing, respiration, and yawning; ringing in the ears; flashes of light before the eyes, and entire momentary loss of sight; giddiness and vertigo; loss of consciousness; sometimes twitching of the limbs, or convulsions—more frequent in children than in adults; syncope, generally profound—passing off and then recurring; finally, syncope ending in death.

On recovering from syncope produced by free hæmorrhage the pulse is soft and jerking; the surface cool, pallid, and shrunken—somewhat as in cholera, and from the same cause, the absorption of water from the tissues to keep up the volume of the blood; hence, also, usually, great thirst—as exemplified in the wounded on the field of battle.

A return of bleeding after temporary arrest by syncope or otherwise is indicated by increasing weakness, by restlessness, jactitation, failure of sight, and recurrence of fainting. Wandering of the mind, deep sighing—which means want of oxygen and red globules—and twitching of the limbs, or convulsions, are suggestive of the near approach of death.

After severe hæmorrhage, the blood left in the body mainly occupies the great vessels, and is kept in the brain and heart by the prostrate attitude of the body; hence *an effort to assume the upright position may be suddenly fatal.*

Before commencing the subject of treatment, I have

but one more remark to make concerning hæmorrhage. A prudent surgeon would not use the knife upon a woman about to menstruate, for this physiological effort at unloading certain blood-vessels is liable to be accompanied by bleeding from a recent wound if present. I have observed this in several instances. On one occasion I removed a fatty tumor from the side of a young woman, in the adjoining hospital, who habitually menstruated irregularly. Her catamenia made their appearance on the third day after the operation, and for nearly a week she lost more blood from the wound I had made than from the natural outlet.

Women have some peculiar forms of hæmorrhage seemingly due to their sexual tendency to periodic outflow, or to the necessity of relief in this way, which, having long been a habit with them, persists in some cases, even after menstruation has ceased. Hæmorrhage from the rectum not due to piles, and sometimes from other sources, will come on at irregular intervals, even after the change of life, attended in rare instances by a peculiar symptom—a dead, waxy whiteness of two or three fingers—the *digiti semi-mortui* (half-dead fingers) of the older authors.

CHAPTER IV.

Hæmorrhage and its treatment—Temporary arrest—Digital pressure—Tourniquet—Compresses—Ligature—Acupressure—Torsion—Styptics.

In commencing the subject of the treatment of hæmorrhage, I must ask you to remark at the outset that all the hæmostatic or blood-stopping remedies of surgery are based upon those methods which have been already recognized as employed by nature, viz.: the natural tendency on the part of the wounded vessel to retract and contract, and of the blood to coagulate—both favored by syncope. Now, the contraction and retraction of wounded vessels and of the tissues which envelop them tend to arrest bleeding, obviously by the pressure which they produce at the point where the breach of continuity exists in the vessel's wall through which the blood escapes. Coagulation facilitates and intensifies this pressure, and syncope aids by securing rest and favoring coagulation.

The purely surgical remedies for bleeding may be all included under the three heads of (1) *Position*, (2) *Pressure*, (3) *Styptics*.

Position insures the aid of gravity to facilitate the flow of venous blood away from a wound and toward the heart. The well-trained surgeon, before applying a tourniquet to the thigh when about to amputate, carefully lifts the limb into a perpendicular position at right angles with the trunk, in order to drain the blood from it and save the gush which would otherwise follow the first stroke of the knife.

Després relates the case of a wound of the external

iliac vein in which the wounded man had the courage and perseverance to keep his thigh forcibly flexed upon the pelvis, because he found that in this position the bleeding was controlled. This was subsequently kept up for a fortnight by the aid of bandages, and at the end of this time the wound of the vein had become permanently sealed.

Position is not without its influence also upon the course of arterial blood. The increased pain and throbbing of a felon on a finger when the hand hangs down would seem to prove this. The popular assertion that the blood runs into the head when the latter is below the level of the body is literally true; and we may add that in this position gravity also prevents the blood from running out again as readily and freely as nature designed when she placed the head at the top of the trunk.

Under the head of *Pressure* are included the numerous devices by means of which it is applied as a remedy—whether *temporarily*—as by the *fingers*, *tourniquet*, or *compress and bandage*—or *permanently*, by means of the *ligature*, *acupressure*, or *torsion*.

Styptics include all the chemical substances which possess any power to stop bleeding when applied locally, including, therefore, *cold*, *cautery*—both "*potential*" and "*actual*"—and the milder but still efficient *astringents*, of which the *subsulphate of iron* is the type. To these may be added the simple *absorbents*, like *cobweb*, *spunk*, and the dry powders which act by hastening coagulation.

In a general way, the old rule is not far wrong, which held that the milder styptics are the remedies for capillary oozing, and simple pressure for venous flow, while the ligature is reserved for arterial hæmorrhage.

We will examine first the means at our command for the *temporary* arrest of hæmorrhage, under the head of *pressure*.

Of these, one of the most efficient, certainly the sim-

plest and most natural, is direct pressure by the finger upon the bleeding point, spoken of technically as *digital pressure.*

It is well to keep the fact well in mind that when a large artery is cut across, the force of the resulting stream of blood is more apparent than real; and that in any sudden arterial spirt *we almost always receive an exaggerated impression as to the amount of blood that is really being lost.* Guthrie, speaking of the necessity of cutting across the axillary artery in amputating at the shoulder joint—one of the localities where the tourniquet can not readily be applied—says: "All that is required to suppress the torrent is to place the end of the forefinger directly against the orifice of the artery, and, with the least possible degree of pressure consistent with keeping it steadily in one position, the hæmorrhage will be suppressed." This, of course, only until an aid can apply a ligature to arrest the flow permanently.

I quote Guthrie, because among Englishmen of the last generation he was the highest authority on this subject, and his work "On Diseases and Injuries of Arteries" is one of the surgical classics which, at your leisure, you will read with profit. Guthrie's outspoken style, and his great opportunities for practical experience as one of the chief military surgeons in Wellington's campaign against the first Napoleon, give his writings a great charm for the young surgeon; and, moreover, they beget confidence by making him familiar with the details of great surgical cases both in the field and in hospital. Guthrie says somewhere that the surgeon need have no fear of being unable to command the hæmorrhage in an operation unless there are more arteries throwing out blood at one time than he has fingers on both hands to stop them with.

To control hæmorrhage in this manner, coolness, and accuracy and precision in applying the finger to the exact point where the pressure is called for, and

steadily holding it in place, are of more importance than force.

It is the intelligence of the surgeon's finger, so to speak, that gives this method of controlling the jet from an artery its value. This is especially noticeable when it is desired to stop the flow of blood through an artery by *digital pressure upon the continuity of the vessel at a distance from a wound*—as upon the external iliac artery in amputating at the hip joint. For this purpose no pad or mechanical substitute can be so well trusted as the educated fingers of an anatomist. The artery must be distinctly felt by the pulps of the index and middle fingers, and it must be pressed against the nearest bone with just enough force to arrest the flow of blood through it. To accomplish this, the amount of pressure required is less than is generally supposed. As I have just said, it is precision and accuracy of application, rather than much force, that is wanted. In case of fatigue, another assistant should place his fingers (or thumb) upon those already in place, or substitute his own for them without any relaxation of the pressure. I have amputated at the hip joint on three occasions—twice at the New York Hospital and once in private—and I experienced no difficulty whatever in either case in having the artery commanded by digital pressure *against the brim of the pelvis.*

To secure certainty and accuracy of digital pressure in a case where prompt amputation at the shoulder joint was necessary, Syme went a step farther. This great surgeon made an incision above the clavicle over the outer third of the subclavian artery, and divided the clavicular insertion of the trapezius muscle so that the finger could more readily reach the artery and compress it accurately against the first rib. This added but little to the extent of the operation, but lessened greatly the danger of losing blood.

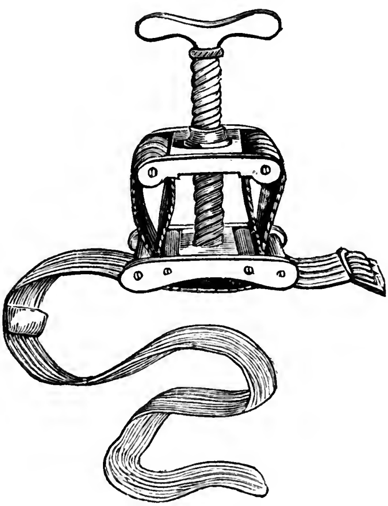
For commanding the circulation through an aneurism in order to bring about coagulation of its contents,

it is contended by the eminent Italian surgeon, Vanzetti, that digital pressure upon the trunk that feeds it is far more certain and successful than the pressure effected by any of the mechanical contrivances invented for this purpose.*

The simplest form of *tourniquet*, or *garrot*, which is the next variety of temporary pressure, consists of a cord or sash tied around a limb between a bleeding wound and the heart, with a cane or drum-stick inserted between it and the skin, so that the leverage in twisting the constricting band shall produce constriction of the limb in as great a degree as the strength of the materials will permit.

The tourniquet in most general use at the present

Fig. 1.



Tourniquet.

day for amputations was invented by the French surgeon Petit, in 1713. When made of good materials and skillfully managed, it is fully equal to any of the

* Jonathan Knight.

numerous substitutes which have been suggested in its place. The picture shows its construction. It is provided with a screw-power, by means of which it can be tightened at will. A tightly rolled bandage of sufficient size and hardness, applied over the artery to be controlled and parallel with its course, makes the best pad.

The more or less complete strangulation of the limb by Petit's tourniquet, and the consequent obstruction to return of venous blood toward the heart, is the practical defect of this instrument, which is otherwise beyond criticism. Various devices have been tried to remedy this defect, mainly by confining the pressure to the artery alone, and to another point on the opposite side of the limb as a *point d'appui*, as in Charrière's tourniquet, used in France, and the instrument known as Signorini's tourniquet; but these are both insecure, and liable to slip. If the surgeon will employ the means already indicated to drain the venous blood out of the limb before screwing up the tourniquet, and will remember to remove the instrument promptly as soon as he has secured the principal arteries, the ordinary tourniquet of Petit will serve his purpose well and safely. It is a wise precaution never to undertake a serious operation in which it is required without having a duplicate instrument within reach, so as to meet the contingency of breakage; and to see, also, that the webbing is sufficiently stout and strong.

The well-known German surgeon, Esmarch, of Kiel, proposed, in 1873, to squeeze all the blood out of a limb before an operation upon it by the methodical application of a stout bandage of caoutchouc, applied from below upward. At the upper limit of the bandage the limb is then strangulated by a sufficiently powerful cord of caoutchouc tubing, and the bandage removed. The limb is thus left in a literally bloodless condition, the venous blood being squeezed out of it and the arterial supply effectually cut off, so that an amputation

or a dissection can be undertaken without any flow of blood whatever—in fact, as on a dead body.

This ingenious device was immediately subjected to trial by surgeons in all parts of the world, and is already proved to be one of the great discoveries of surgery. It has been demonstrated that a whole limb can be entirely deprived of its blood supply in this manner for several hours without danger or even serious inconvenience. Mr. Christopher Heath, of London, has carried it safely to four and a half hours, and Mr. Barwell to five hours; and, in an exceptional case in Germany, the bloodless condition was kept up in the fore-arm and part of the arm, in a boy, for no less than *fourteen* consecutive hours, for recurring hæmorrhage from a wound of the hand, which was permanently arrested. (From "Wiener Mediz. Wochenschr.," June 21, 1878, quoted in Weir's paper on "The Elastic Bandage in the Treatment of Aneurism," in Hays's "Journal," January, 1879.)

The phenomena which followed the prolonged compression in this case furnish a good illustration of the dangers which are liable to result from the use of this device if carried too far. "As soon as the bandage and tubing were removed," it is stated in reference to this case, "rapid swelling with intense redness came on, sharply defined at the constriction produced by the tubing. This in an hour took on the appearance of an acute diffused inflammation, and was associated with a motor paralysis in the hand of a severe degree. Under the use of cold compresses the redness and swelling quickly disappeared in from three to five days, but the paralysis remained for two or three weeks" (p. 41).

Thus for one or two, or even three hours, this condition of bloodlessness may be kept up by strangulation without danger of serious consequences, and the worst results from keeping it up longer would be intense redness from congestion, temporary paralysis from pressure on nervous tunks, and possibly gan-

grene, for the escape of the boy whose case I have quoted was certainly exceptional, and could not be fairly anticipated in the case of an adult, or in a lower limb. In the cases collected by Professor Sands ("New York Journal of Medicine," January, 1875) for the purpose of ascertaining the safety of this mode of commanding the circulation, there was one in which amputation was done in the bloodless condition, and the flaps subsequently sloughed. But this accident is liable to take place occasionally under ordinary circumstances.

After an operation by Esmarch's method, and when the principal arteries have been tied and the strangulating tubing removed, there is, not infrequently, quite free capillary oozing; but it soon subsides under the application of cold and slight local pressure. This has been attributed to temporary vaso-motor paralysis. No injurious consequences as regards the subsequent healing process have been observed to follow the use of Esmarch's method; and, on the whole, it is to be regarded as a most valuable addition to the resources of the surgeon in controlling hæmorrhage. As to its other applications, such as for the cure of aneurism, we shall recur to them later.

After grasping the facts connected with this great surgical novelty, it seems somewhat trivial to speak of the ordinary *compress and bandage* as one of the systematic methods of applying pressure for the control of bleeding; and yet this is the time-honored and typical resource of the surgeon, of which Esmarch's bandage is only a modification. The compress and bandage are applicable to a much wider range of cases, and are always at hand, at least for temporary use, in all varieties of surgical injury, whether for a cut finger or a wound of a large artery.

Here a case occurs to me in which the late Valentine Mott believed that he successfully cured a wound of the subclavian by the compress and bandage alone.

A surgeon had been removing a glandular tumor from above the clavicle at its outer half, and committed the error, against which I have already warned you, of drawing out the tumor and cutting off its deep connections at a stroke. This is a keen temptation when a dissection becomes deeper than had been anticipated, especially when it is leading in the direction of a large artery; but for this very reason it is the more dangerous. Large arteries are seldom dangerous when approached cautiously by a good anatomist, but they are to be treated with formal respect.

In this case, however, a "fearful gush" followed the last stroke of the knife, and the wound was rapidly crammed with whatever was at hand; and, while an assistant made pressure upon the temporary compresses, the principal sought the aid of counsel. On his arrival, the great surgeon was forced to admit, on the evidence of the operator, that the subclavian had been wounded. As it was impossible to make pressure upon the artery between the suspected wound and the heart so as to permit a verification of the fact by further dissection and inspection, Mott adopted another course. He cut up a fine, dry sponge into small pieces, and then, removing the temporary compresses and commanding the bleeding by the finger by pressing the trunk of the artery against the first rib, he placed a small piece of the sponge upon the point from which the blood issued, another—a little larger—upon this, and so on, using larger pieces successively until the cavity of the wound was packed full. Over all a compress of folded patent lint was placed, and this was retained in position by what is known as a *spica* bandage. There was no more bleeding.

The outer compresses were carefully taken away during the second week, and gradually the deeper pieces of sponge, as they became saturated with pus. But it was more than a month before the deepest fragment of sponge was finally disengaged, for it had be-

come surrounded and confined by granulations which had penetrated its pores. After this the granulations rapidly filled up the cavity of the wound and the cure was complete.

The compress employed in this case constituted a variety of what is known as the *graduated compress*, in which the point of a pyramid is kept accurately in place by the pressure made by a bandage applied over its base.

A *compress* may be made of lint, oakum, wool, prepared cotton, or any convenient material; and its wide range of application, and the fact that the materials for this dressing are always at hand, will keep the compress and bandage always in popular use. It is often employed to control arterial bleeding in wounds of the palmar or plantar arches, where it has been found too difficult to reach the wounded vessel and apply the ligature. But pressure effected in this way is not free from the danger of causing gangrene of a limb by depriving it too completely and for too long a time of its supply of blood. *It is always better in these cases to tie the wounded artery in the wound;* and now that we have the bloodless method of Esmarch at our command, there is no reason for being satisfied with any temporary expedient, which at the best, in wounds of this region, are uncertain. In searching for a bleeding artery in a wound, the tourniquet possesses one advantage over Esmarch's caoutchouc bandage—namely, that you can relax it at will and immediately screw it up again. This manœuvre, by causing a momentary spirt from the artery, renders its position more easy of detection.

Pressure is also applied in surgery, as in midwifery, by means of the *tampon*, as used in plugging the nostrils behind and in front to control obstinate epistaxis; and in packing lint or sponge around a metallic tube to arrest bleeding from the wound after the lateral operation of lithotomy; or in plugging the rectum by the double sponge for bleeding at its outlet.

The *ligature*, the most important of all the surgical remedies for the permanent control of hæmorrhage, was first systematically employed and popularized, about the year 1550, by Ambrose Paré, surgeon to Charles IX, known as "the father of French surgery." Before his day the actual cautery was the main reliance of the surgeon for the control of arterial hæmorrhage, in operations and under all circumstances. The furnace was kindled and the cautery-irons put into the fire as the first preparation for any surgical operation involving flow of blood.

At first common, coarse, hempen thread was employed for ligatures, with little regard to bulk. The ends of the threads were not even cut off. At this period wounds were rarely allowed to heal by the first intention; it was regarded as better and safer surgery to secure their healing by the slower process of granulation, and, therefore, the presence of the bulky ligatures in a wound was not regarded as a disadvantage. The bleeding vessels were tied tightly in the wound; the bleeding was found to be effectually controlled and the vessel eventually obliterated, the threads being generally thrown off without assistance as healing by granulation was accomplished.

Sometimes the wound healed over a ligature before it had been thrown off, as in John Hunter's first case of ligature of the femoral artery for aneurism, as late as 1785; and here, as almost always happens, an abscess formed subsequently to bring about its discharge.

Some years ago I saw in the Museum of the College of Surgeons of Dublin a preparation of the parts taken from the patient in whom the great Irish surgeon, Abraham Colles, tied the subclavian artery, in 1815, for aneurism—the first instance in which this vessel had been tied in its first portion—and both ends of a thick, cord-like ligature were still hanging from the artery in the neighborhood of a great, ragged ulceration in its coats.

As late as 1839, Roux, the celebrated surgeon of the Hôtel Dieu of Paris, employed several heavy, tape-like ligatures in tying the primitive carotid for aneurism.

Jones, an original English observer and experimenter, whose classical work "On Hæmorrhage" was published in 1824, first accurately demonstrated the local phenomena which follow the application of a ligature to an artery, and the several steps of the vital process by which the vessel, in successful cases, is obliterated by it without loss of blood.

These steps are as follows: As an ordinary ligature is drawn tightly on the vessel, its soft innermost and middle coats are cut through transversely, and curl inward. Their edges, thus approximated, grow together. The blood contained in the artery at the moment of ligature forms a clot which extends from the approximated cut edges of the artery upward to the first branch given off above the point of ligature. This clot frequently contracts adhesions with the cut edges of the internal coats, and also with the internal surface of the artery.

FIG. 2.

Artery ligated in the continuity. Thrombus; after *Froricp.*

The *clot* has been regarded as an important factor in the process of obliteration of a ligated artery; but this process is often accomplished without it, and the vessel has been effectually sealed by the simple growing together of the introverted edges of the divided arterial coats.

It was afterward found, mainly through Jones's experiments, *that the process of obliteration of an artery by a ligature fails less frequently the smaller the size of the ligature applied and the less the surrounding parts are disturbed in the operation.*

The ligature is finally separated and thrown off from the tied artery by the following process: The portion

of the vessel constricted by the ligature has been, of course, killed by the strangulation, and a minute slough is the result. This slough is gradually detached by the ulcerative process from the living tissues with which it was continuous; and, when the process of detachment is completed, the ligature falls spontaneously, or can be readily pulled away from its connections, and the minute slough, comprising all the coats of the artery, will be found embraced in its loop.

Thus, an artery to which a ligature of hemp or silk or wire has been applied tightly, so as to strangulate it, is not only *obliterated*, but *necessarily completely divided or cut across.*

The material employed for a ligature should possess the qualities of strength in small compass, and flexibility. Our tissues tolerate best the contact of metallic and of animal substances. Hence the favor enjoyed by fine silver or iron wire, silk, and catgut.

What is especially to be desired is a material that can be relied upon safely to occlude an artery without interfering with the quick healing of a wound. Hempen thread does not meet these conditions. As we learn from Hunter's famous case, if the wound heals over the foreign substance, an abscess must form later to float it out and finally get rid of it.

I don't know who first employed silk for ligatures, but its superiority over thread was so obvious that it has been, until recently, almost universally employed. Most of the great triumphs in the surgery of the larger arteries have been gained by its aid. Valentine Mott first tied the arteria innominata in 1828, and had successfully cured an otherwise inaccessible aneurism by ligature of the primitive iliac before this (in 1817), and he employed silk in both cases.

But the silk ligature, although an obvious improvement on hempen thread, had also certain great practical disadvantages. Although an animal substance, it could not be trusted to undergo absorption in our tissues, and

it has been found necessary to keep the wound from closing entirely for one or two weeks at least, or until separation of the ligature by natural process has been completed.

The presence of this foreign body, or of a number of such foreign bodies, in the case of a large wound, such as an amputation, necessarily prevents entire and prompt union throughout the whole extent of the wound, which, in their absence, might in many cases take place.

Moreover, each hempen or silk ligature holds in its grasp a mass of dead tissue—small, to be sure, but possibly rotten and offensive, and, as we have since learned to believe, fully capable, in a certain proportion of cases, of poisoning the blood by septic material capable of absorption by the capillary vessels in contact with the slough, and of begetting the diseased condition that we call *septicæmia.*

Veitch, an English surgeon, recognizing the advantage of having as little as possible of the foreign material in a wound, cut off one end of the ligature; but the other end was necessarily left, by which it could be pulled away when fully separated. And this remaining end of the ligature was always saturated with putrid pus, lying in a track often many inches in length and lined by a granulating surface capable of absorbing.

I do not wish to leave the impression on your minds that the knot of a silken ligature, if both ends are cut off and the wound entirely closed, is never absorbed or otherwise disposed of than by creating an abscess for its expulsion. In exceptional cases, when both ends of the ligature have been cut off, it has done its duty in stopping the bleeding, and has never afterward been heard of; but this result, of course, can never be counted on with certainty; *the rule is subsequent inflammation and abscess.*

In 1848 I removed a large fibrous ovarian tumor from a young woman, and, in separating some omental

adhesions from the surface of the tumor, there was bleeding at several points of the omentum, to each of which it became necessary to apply a ligature. I used the finest floss-silk, and cut off both ends, closing the abdominal wound entirely. The case did perfectly well, and the ligatures were never heard from.

Here, in my opinion, the little knots became *encapsulated*, or *encysted, a result which not infrequently happens when a foreign substance, unirritating in its nature, is left imbedded in our tissues.*

The explanation of this phenomenon—which has often taken place in cases in which bullets have been left unextracted—is as follows: The granulations which have sprouted around the intruding substance, instead of furnishing pus and forming an abscess, *develop into fully organized connective tissue*, and form a little sac or bag around it. Thus disposed of, the foreign substance, as a rule, is never again heard from.

A case was reported at the London Pathological Society within a few years in which an old soldier who died in one of the hospitals of London was found to have an old-fashioned musket-bullet—an ounce-ball—encysted in the cavity of his chest, which bullet he had carried there since the battle of Waterloo.

The absence of irritating qualities in the extraneous substances which are thus encapsulated is a noticeable feature in those cases. Where the foreign substance is rough externally, or chemically irritating—as in the case of a copper bullet, its presence excites the continued formation of pus, and nothing short of an abscess can be expected; and it is to be understood *that this latter result is the rule.*

At the present time, while the claims of different materials for ligature are exciting keen discussion, it is well to keep in mind all that can be said for and against silk, which has so long enjoyed the preference of surgeons.

It has been urged in its favor that ligatures of silk

or thread left in a wound, although they prevent prompt healing and may act as poisonous foreign bodies, nevertheless subserve a useful purpose by providing outlets for drainage of fluids from the wound, and thus hindering the formation of deep collections of pus. This argument has had a certain amount of force, but the statistics of success in rapid and safe healing are at present in favor of metallic or, still better, of soluble, substitutes for the silk ligature, with drainage by separate means and devices which can be more promptly dispensed with as soon as their object is accomplished.

Metallic wire was first proposed as a material for sutures and ligatures by a French surgeon named Lemonnier (v. Dupuytren, "Leçons orales"), in 1829, but it was not brought into practically successful use until twenty years later, by our countryman, Marion Sims, in connection with his great improvement in the operation for vesico-vaginal fistula. It was soon found that the tissues would heal kindly over wire; that a loop of it could be left in a wound without an abscess following—a result obtainable only exceptionally with silk; that, in short, the surgeon could count upon its becoming encapsulated.

Our countryman, Benjamin Howard, took advantage of this peculiarity of the metallic ligature, and, by some ingenious experiments on animals, proved that a loop of fine silver wire *thrown around an artery so loosely as not to divide its inner coats, but merely to obstruct its current*—its ends being cut off and the edges of the wound entirely closed over it—could be relied upon to obliterate a vessel as large as the carotid of a donkey, *and without dividing it.* He found that this degree of obstruction by the unirritating metallic loop would bring about coagulation up to the first branch, and, finally, permanent closure of the compressed trunk.

The celebrated Simpson, of Edinburgh, had already arrived at the same result by means of temporary com-

pression of arteries by long needles—the method since known as *acupressure.* In short, this latter mode of permanently occluding arteries was a fact acquired for science even before the revival of metallic sutures by Marion Sims, and Simpson had formally proposed it as a substitute for the ligature in 1849. It is well to recognize clearly the advantage claimed for the loose-wire loop of Howard, and for the acupressure needle of Simpson. It is that by them an artery may be safely and permanently occluded *without actual division of the vessel.* As a safeguard against secondary hæmorrhage, this is certainly an advantage.

Neither the wire loop, however, nor acupressure, has to any extent taken the place of the silk ligature.

Dr. Jameson, of Baltimore, and Dr. Wagner, of Charleston, under the inspiration of Physick, of Philadelphia, had formerly tried animal ligatures in the form of the split sinew of the deer, in the hope that this pure, white fibrous tissue might dissolve or disappear after occluding an artery—so that the ends of the ligatures might be cut off and the wound safely and entirely closed over them. Professor Agnew, of Philadelphia, tells us that he has employed the same material obtained from the giraffe. For some reason these white fibrous tissue threads, the trial of which had its origin in this country, have not been generally adopted.

Meanwhile, Mr. Joseph Lister, formerly of the Royal Infirmary of Edinburgh, now of King's College Hospital of London, had conceived the idea of accomplishing the healing of wounds, as a matter of certainty and without suppuration, *by enveloping them in a "germ-killing" medium.* Inspired by Pasteur's discovery that fermentation was due to the action of microscopic vegetable parasites present in great numbers in the air, he assumed that the same cause accounted for the festering and bad behavior of all wounds; and strove to prevent this by excluding or destroying the germs of these organisms. His experiments date back

to 1860, and were so promising with carbolic acid—a substance derived from coal-tar by destructive distillation, and first brought into notice about 1850—that he adopted it as the most available germicide. Mr. Lister at first saturated silk ligatures with carbolized wax, tied his arteries with ligatures thus prepared, cut off both ends, and sealed the wound with the carbolic-acid dressing. The result was that the *prepared silk did not cause abscess, but became encapsulated.* This result was verified by Dr. Eben Watson and Professor Fleming, of Glasgow.

But Mr. Lister, after several years of patient effort in experimenting with common *catgut*, succeeded in so preparing this substance, without any sacrifice of strength, that in a short time after its application to an artery it will blend with the tissues and entirely disappear. A ligature of *prepared catgut* may be relied upon, in other words, effectually to occlude an artery for a sufficient length of time to secure coagulation of its blood and its obliteration, and then to dissolve away and disappear without causing the division of the artery.

Professor Fleming's published experiments demonstrate this to be true. He buried fragments of prepared catgut, and also of carbolized silk, in recent incisions into the tissues of dogs, and, after some days, when the wounds had healed, he killed the dogs and carefully examined with the microscope into the condition of the buried materials. Fragments of the carbolized silk could still be distinguished in the wound after complete cicatrization. They were imbedded in embryonic tissue—i. e., in granulation cells—but the latter presented no appearance of assuming the character of pus; on the contrary, they were obviously undergoing development into connective tissue for the purpose of forming a cyst or capsule around the fragments. How the presence of carbolic acid—the germ-killer—in these ligatures, and its use in their preparation, tends to pre-

vent suppuration, will be explained hereafter, when we come to study the healing of wounds.

As for the *prepared catgut* buried at the same time, its outline only could be recognized as a trace of translucent material presenting the shape of the original fragment; and, in its very substance, embryonic cells could be readily distinguished in process of growth and development—as in a blastema or bed of plastic lymph. Hence it may be said that the PREPARED CATGUT LITERALLY DISSOLVES AWAY AND BLENDS WITH THE TISSUES.

After this striking statement it would seem that the desideratum had been attained as to *the best material for ligatures.* With prepared catgut ligatures there are no longer foreign bodies necessarily left in wounds to prevent their consolidation and to poison the blood. Professor Lister told me himself, in 1876, that he was willing to tie the innominate artery with one of his prepared catgut ligatures and cut off both ends of it, in full confidence that the wound would consolidate promptly, without suppuration, under proper dressing. Now, in such an event, as the great vessel will have been obliterated *without being cut through*, and the ligature will have blended with the tissues almost as promptly, the great danger of death by secondary hæmorrhage at the time of separation of the ligature—which has heretofore caused the failure of this operation—will be certainly escaped.

Sufficient success has been attained since this date in the use of the prepared catgut ligature for the obliteration of large arteries to justify Lister's confidence.

The catgut is prepared by being soaked for a few days in a solution of carbolic acid in sweet oil, with the addition of a small amount of chromic acid. It is claimed that the latter renders the catgut pliable without diminishing its strength, and deprives it of all tendency to become untied when placed around an artery.

Cases have been recorded showing that the catgut

ligature has proved inefficient, that it has dissolved away before the ligated artery has had time to become safely obliterated, and, the temporarily interrupted current becoming re-established, hæmorrhage has followed with a fatal result.

I am able to state, however, that these cases of failure, which occurred before the latest improvements in the preparation of ligatures, have become less frequent, and that the catgut ligatures, as now prepared, seem to be steadily growing into the confidence of operating surgeons. Although they are being constantly more generally employed, we hear of few, if any, unsatisfactory cases.

For convenience of applying ligatures in a wound, the *forceps* and *tenaculum* are employed to seize and draw out the bleeding vessel from the surrounding parts, so that the strand of silk or catgut may be thrown around it separately and accurately. The ligature should be tied with moderate and careful tightness, and by a *square* knot that will not slip, cutting off one end of the ligature if of silk, and both ends if of prepared catgut.

Although carbolized silk tends to become encysted more readily than the ligature of unprepared silk, we have not sufficient evidence of the certainty of this result to warrant cutting off both its ends, as a rule.

Artery forceps should meet accurately at their points, which are roughened within, or provided with teeth, to prevent slipping; outside they should present, when closed, a smooth, conical surface, tapering to a point, off which the knotted loop of a ligature may readily slip on to the artery which is being held between their teeth, so as not to include the point of the forceps when tied. A slide, or spring catch, by means of which the forceps may be securely locked upon the artery, is very useful, especially when assistants are wanting.

It is desirable to include as little of the surrounding

tissues as possible in the knot of a ligature along with the artery.

Sometimes the exact bleeding-point can not be made out on the surface of a wound, or the arterial orifice can not be distinguished, and the vessel can not be drawn out by the forceps; or the surrounding tissues are so friable that they give way under the sharp bite of the forceps; or they are, perhaps, too dense and ligamentous to be picked up by them. Here the *tenaculum* is useful to transfix a little mass of tissue and draw it out so as to present a sort of pedicle around which a ligature may be thrown, and then tied tightly, after which the tenaculum is withdrawn.

Where the unyielding rigidity of white fibrous tissue, as of tendon or intermuscular septum, prevents a ligature thus applied from holding, the tenaculum may be replaced by an ordinary straight suture-needle, threaded with silk or wire, to furnish means for its subsequent withdrawal, and over and around this needle a ligature may be tied—the whole being left in place. Or a mass of tissue, including the bleeding-point—where it can not be isolated—may be transfixed by a needle, straight or curved, but carrying a double ligature in its eye; the needle is then cut loose and one of the ligatures tied tightly around each half of its base.

It sometimes happens, in amputating the limb of an elderly person, that you will meet with an artery—generally one of the tibials—so thoroughly degenerated by calcification of its coats as to crackle and give way under the constriction of a ligature. In this case a little conical plug of soft wood may be fashioned offhand, a ligature attached to its base, and its point inserted into the gaping mouth of the artery with force enough to retain it in place. I employed this device with success in amputating below the knee, in an old lady, for senile gangrene of the foot which had limited itself at mid-leg, and she made a good recovery.

In closing a wound, all the ends of insoluble (i. e.,

silk) ligatures applied to its arteries should be brought out either separately, in parcels, or in mass, by the shortest and most direct routes, their possible use in draining fluids from the deeper parts of the wound being always kept in view; and their points of exit—in order to facilitate this desirable end—should be *located, as far as may be feasible, in depending positions.*

As I have already mentioned, this is not the most desirable method of drainage, but it should not be lost sight of when ligature-ends are necessarily present.

It is even advisable sometimes to secure a depending outlet for both ligatures and drainage by making *a new opening especially for this purpose* through the substance of a flap, or through one of the walls of a wound, bringing all the ligatures through this outlet and closing the wound itself accurately.

The ends of insoluble ligatures, as I have already shown, are ready to come away as soon as the dead portion of the vessel—that which has been constricted by them—is thrown off by the process of ulceration and granulation in its adjacent portions; i. e., as soon as the ligated vessel has been completely cut through and severed from its connections. In a small artery this process is accomplished in a week, and in an artery of the largest size in about double this time.

The exact moment at which the ligature becomes thus separated and ready to be withdrawn can only be determined by gentle trials in the way of traction, beginning in from a week to ten days, according to the time of life and the size of the artery. If a ligature upon an artery of moderate size—a tibial, for example—resist moderate traction after a fortnight, it should be jerked away by force, or attached to a caoutchouc band so as to be subjected to constant traction. The solid and permanent closure of the artery will have been certainly effected in a fortnight, and the extra tenacity with which the ligature holds on is probably due to the inclusion of some white fibrous tissue in the knot

around the artery—and this sort of tissue is very slow to dissolve, even after it has died.

For an artery of larger size three weeks might be allowed. A ligature, if left too long upon an artery, is liable to become rotten, and to break in the wound when finally jerked away. This accident might be followed by prompt closure of the track in which the ligature had been lodged; but later an abscess would be likely to form, and, with its contents, the portion of ligature left behind would be finally floated out.

If soluble catgut comes permanently into general use for ligatures, as seems likely at present, many of these considerations will lose their force.

There are resources at the command of the surgeon to control bleeding from an artery so deeply situated in a wound that a ligature can not be applied upon it. Among these I may mention small clamps of sheet-lead, or split shot, or the little spring clamps known as *serres-fines*, or larger steel forceps so constructed as to remain closed with a certain amount of force when placed in position.

These latter contrivances possess an additional value. They take the place of assistants in an extensive or tedious operation, holding vessels safely until the surgeon is ready at his leisure to apply ligatures to them. In bleeding from bone, as after an amputation, the device of stuffing the hole with pieces of prepared catgut cut from a ligature has succeeded.

Before leaving the subject of the ligature, by far the most important of the surgical hæmostatics, it will be profitable to make a brief summary of the different circumstances under which this valuable remedy is employed in surgery, and of all that is known concerning its mode of action. These remarks will apply equally to the ligature of prepared catgut and to ligatures of silk or other materials.

Erichsen tells us that ligatures of thread were applied to bleeding arteries, under exceptional circum-

stances, by Ætius, a Roman surgeon of the fifth century. It was a thousand years later that Ambrose Paré generalized its use, as a substitute for the red-hot iron, by tying the ends of cut vessels in a wound, as the habitual resource for controlling hæmorrhage. But the usefulness of the ligature as a surgical remedy was vastly increased by Hunter more than two centuries afterward, when he first applied it to the continuity of an arterial trunk for the cure of aneurism. This bold and original achievement, by its wonderful success, opened up new uses for a remedy which was already growing old: uses as a remedy for disease; for cutting off the supply of blood to growing tumors other than aneurisms—e. g., vascular and cancerous tumors—so as to starve them out by cutting off their sources of nourishment; to diminish the loss of blood during the removal of vascular tumors when sufficiently accessible to warrant the use of the knife for this purpose; and it has even been employed as a remedy to lessen the afflux of blood to parts threatened with destructive inflammation.

These additions to the scope of the ligature as a surgical remedy are properly mentioned here, for they throw new light upon the way in which it acts in stopping the bleeding from arteries in a wound by illustrating the effects produced upon what is called the *collateral* circulation of a part by tying a neighboring artery in its continuity.

Thus, for example, it is an important canon of surgery that in a wound a ligature should be applied to *both ends* of every artery large enough to have a name, whether partially or completely divided. Especially if the vessel be only partially divided, a ligature is to be applied on *both sides* of the lesion in its walls—i. e., on the *distal* as well as the *cardiac* aspect of the arterial wound—and then the division of the artery is to be completed between the two ligatures. I have already related a hospital case in which this was done. To illustrate further this important *rule, which demands*

the ligature of both ends of a wounded artery, I will cite another case recorded by Sir William Lawrence.

A man was wounded in a brawl, and left fainting and half dead on the street. When found and cared for, a wound was discovered involving the brachial artery; a ligature was applied to the upper end of this vessel and the man sent to a hospital. On arrival, he was found excessively exhausted and exsanguine. The artery was found tied in the wound, and there was no bleeding. He was put to bed and cordials administered. Some hours afterward, while sleeping, it was discovered that free bleeding had come on again from the wound. The nurse summoned the house surgeon, who found a free flow of dark-colored blood from the *distal* end of the divided brachial artery—not the end which had been tied, but the distal end. After some delay a ligature was applied at this point and the bleeding arrested; but the patient was so much exhausted by the second hæmorrhage that he failed to rally, and died in a few hours.

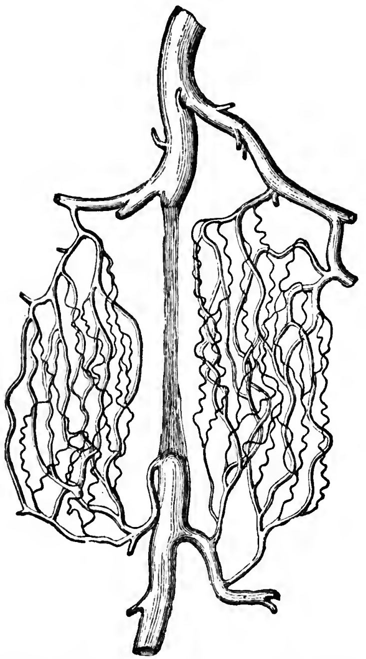
This case illustrates the fatal consequences of not applying a ligature to the distal as well as to the proximal end of a divided artery, and it explains the rule of surgery, just enunciated, which requires that a ligature be applied to *both ends of every artery wounded in its continuity, whether it be completely divided or not, whether it bleed or not.* If there is no bleeding from the distal end, it must be searched for and tied all the same; otherwise the wound is not safe.

It is hardly necessary to explain to you that the proximal end of a divided artery means the end nearest the heart; but it may be as well to emphasize the fact demonstrated in the case just cited, namely, that *fatal hæmorrhage may take place from its distal end.* This *distal* hæmorrhage has its source in what is known as the *collateral circulation*—i. e., the circulation kept up through the inosculations which exist between the branches given off by the wounded trunk *above* the

wound and those given off by the same trunk *below* the wound.

When the circulation is interrupted through the main trunk of an artery, the blood thus diverted from its natural channel ultimately reaches its destination by traversing these inosculating branches. Notice that the current through the lower set of branches is *retrograde*, because the blood flows backward through them into the main trunk below the point of interruption. These inosculating branches of the wounded artery, or of the vessel ligated in its continuity, as for the cure of aneurism, constitute, therefore, its *collateral circulation.* The blood reaches the lower end of a limb—as, for example, when the brachial has been tied — somewhat slowly through these collateral channels; more slowly, of course, if the action of the heart has been weakened by previous loss of blood; and when it reaches the main trunk below the point of ligature, it flows most readily in the direction in which there is the least resistance. This is obviously backward, through the main trunk, and thus it escapes through the distal opening—unless that opening has been sealed by a ligature. This was the source of the second

Fig. 3.



Femoral artery of a large dog, injected three months after ligation. After *Porta.*

and fatal hæmorrhage in the case related by Lawrence.

If the distal end of the divided artery has been tied by a wise and provident surgeon, then the blood brought back through the collateral channels is carried onward through the main trunk, beyond the point of ligature, in the normal route of the circulation, to its destination.

The phenomena attending this effort to keep up the blood supply of a limb when the flow through its main trunk has been obstructed are of great interest to the surgeon. It is obviously a conservative effort. If it were not accomplished, every limb in which the main arterial trunk has been obstructed would fall into gangrene. This catastrophe was assumed by the older surgeons to be a necessary consequence of an interruption of the arterial current through the main trunk of a limb. The process by which its function is kept up by the establishment of a collateral circulation was not understood before John Hunter began to tie great arteries in their continuity for the cure of aneurism. This was the great practical achievement of his genius. His predecessors hesitated to do what he did because they feared gangrene, because they did not realize the extent of nature's resources in this matter of collateral circulation. Hunter gained his knowledge of nature's ways by experiments on animals. These experiments have been largely repeated, and their results in men as well as in animals have become a part of our knowledge, constituting no unimportant part of the science of surgery.

From what I have said concerning the collateral circulation, you will now understand why the flow of blood from the distal end of a divided or wounded artery is slow and gradual, and why it has not the arterial jet and impulse; and also why it is darker in color, like venous blood—for which, in fact, it is somewhat liable to be mistaken. It has come a long way around through

the tissues, and has lost some of its oxygen. But you will recognize also that, although slow, it is sure; that the circulation is certain to be re-established unless the part falls into gangrene; and that when it is re-established there will be an escape of blood from the distal ends of arterial trunks unless previously sealed by the efforts of nature, or prevented by the ligature.

Our summary of the uses of the ligature is now readily completed. It is to be applied: 1. To the end of every recognized artery divided in amputating a limb, and also to those which give blood after the operation is completed and the tourniquet removed. 2. To both ends of every artery partially or completely divided which can be made to bleed in a wound—e. g., in an ordinary surgical wound, as, for example, that made in removing a tumor, where every vessel that emits a jet is to be caught and tied; at once when the tumor is large or vascular; after its removal if small. 3. To both ends of every artery large enough to have a name, whether partially or completely divided, or whether bleeding or not. 4. To the continuity of an unwounded artery when it is desired to arrest its stream; as for the cure of aneurism; for cutting off the arterial supply from a growing tumor; for the purpose of diminishing the hæmorrhage during the removal of a tumor—in which case the operation for removal must be done immediately after tying the artery and before the collateral circulation has become established; and, finally (5), for lessening the afflux of blood to inflamed parts. Of each of these applications of the ligature we shall meet with examples hereafter.

Having finished with the ligature, which is certainly the most efficient and the most widely employed of all the surgical resources for controlling the flow of blood, we shall devote a few words to *acupressure.*

Acupressure is the name given by Sir James Simpson to the method which he proposed as a substitute for the ligature as a mechanical remedy for bleeding

arteries. As the name implies, this method consists in applying pressure across an arterial trunk by means of a steel needle, by taking a purchase, as it were, from the adjacent tissues. The needle, which may be five or six inches long, with a solid head, is quilted into the tissues so as to firmly compress an artery, just as a pin is employed to confine a flower-stem in contact with the lappel of a coat.

In this device advantage is taken of the tolerance by the living tissues of metallic contact, and also of the certainty with which it has been proved that an artery may be obliterated in a limited time by accurate pressure competent to arrest the flow of blood through it, even though its inner coats have not been divided.

The advantages of this method of occluding arteries —say, in an amputation—are that the needles can be withdrawn in from one to three days without having caused suppuration, that the arteries subjected to pressure are certain to be obliterated, and that the prompt consolidation of the wound is unimpeded by the presence of any foreign body.

Several modifications of the mode of applying the needles have been devised, smaller needles with eyes carrying fine iron wire to facilitate their withdrawal being substituted under varying circumstances for the longer solid needles.

Acupressure has been largely tried, more extensively in Scotland, where Dr. Pirrie, of Aberdeen, has been its strongest advocate. Some of its varieties will no doubt continue in use, but the principal argument in its favor, which was based on the defects of the silk ligature, has lost its force since the introduction of the prepared catgut, which is more simple and easy of application, and accomplishes the same ends with equal certainty—*these ends being the occlusion of arteries without causing suppuration and without leaving foreign substances in a wound to interfere with rapid healing.* I have tried acupressure, and can confirm all

that was claimed for it before prepared catgut came into use. Where a surgeon lacks competent assistants to tie arteries for him, a supply of straight suture-needles and fine iron or silver wire adds materially to his resources.

The greater tolerance of the contact of metal on the part of the tissues remains as a fact acquired for surgical science. This useful knowledge has many applications in surgery outside of hæmostatics.

Acupressure, to conclude what I have to say about it, has not advanced in general use. It stands about where it did five years after its first introduction thirty years ago. The ligature yet holds its place as the great surgical remedy for arterial hæmorrhage. The objections against the ligature of silk were somewhat overstated and exaggerated by the earlier advocates of acupressure, and, in the natural reaction against this error, acupressure lost ground.

When pyæmia, erysipelas, and the septic diseases have been prevalent in hospitals, threatening danger to suppurating wounds, the wounds treated by acupressure, in my experience, have not been found to escape. And, when these malign influences are absent, the greater or less value of silk ligatures in draining a wound counterbalances, in the opinion of many practical surgeons, the advantages of early and entire union in a large class of cases.

Torsion is a mode of sealing up the open end of an artery which has been cut across by forcibly twisting the vessel upon itself. This method was popularized by the French surgeon Amussat, after a very thorough series of experiments on animals, in 1829.

Torsion is best accomplished, according to this surgeon, by means of two pairs of forceps, the artery being seized by a cut end and drawn out by one pair of forceps furnished with a spring or catch, and then grasped transversely, a half inch or so above, by the other, after which the first pair of forceps is rotated three or

four times on its long axis. By this manœuvre the internal and middle tunics of the artery are torn across, so that they retract and curl inward in such a manner as to plug the caliber of the vessel, while the more unyielding outer fibrous coat is so twisted upon itself, and its component fibers are so pressed and felted together, that they effectually complete the vessel's occlusion. In Amussat's experiments on dogs he attempted in vain to force water, by means of a powerful syringe, through arteries which had been subjected to the process of torsion. Vessels of the size of the axillary and femoral arteries have been successfully sealed by torsion in man; and for vessels of the size of the radial and under, it has been extensively proved by the test of clinical experience to be a safe and sure means of closing an artery.

The ultimate obliteration of the twisted vessel is accomplished by the exudation of plastic lymph from the lacerated surfaces; by this they are consolidated, and the plastic lymph is finally organized and developed into connective tissue, or that form of it which is known as cicatrical tissue.

Torsion is applicable only to arteries which have been divided across completely, as in a wound left by amputation. The advantage has been claimed for this hæmostatic method that it leaves no foreign matter in a wound to interfere with its entire closure and prompt union. But the end of an artery has been so nearly twisted off as to cause its death, in which case there would be a slough in the wound, or pus might form at the seat of laceration; and in some rare cases torsion does not stop the bleeding, and the ligature is required after all. Moreover, it takes more time often to twist an artery of any size than to tie it. Hence, although largely tried for fifty years, this method has not taken the place of the ligature. It is mostly employed to arrest the flow from smaller arteries during the progress of an operation—to save time and prevent masking

of parts by sealing arteries which would gradually close themselves if let alone; and it is rarely applied to arteries of any considerable size. If carbolized catgut ligatures prove ultimately reliable for general application, torsion of arteries will be still less used in the future.

As an American modification of torsion, Dr. Fleet Speir, of Brooklyn, has devised an ingenious artery constrictor, which can be applied upon the continuity of an artery so as to divide its middle and inner coats, and then to invaginate the *external* coat of the artery within the tube of the constricting instrument to a sufficient extent to roll up the two inner arterial tunics into an impassable barrier equally efficient with that produced by the method of torsion. After this, the instrument is withdrawn and the wound closed. This ingenious device has been successfully applied to the carotid three times, to the femoral and the brachial, each once; in each instance it has caused obliteration of the artery, and, as Dr. Speir informs me, has in four cases caused a cure of aneurism.*

Styptics will next occupy our attention. Since the introduction into general use of the *subsulphate of iron*, which is justly regarded at present as the type of the styptics, a long list of substances of less value, handed down to us by tradition under this title, have lapsed into disuse.

This cheap and soluble substance was first known as *Monsel's salt.* Its use was introduced into this country by Drs. Hutchison, Miner, and Isaacs, of Brooklyn, of whom the former published a notice of it in the "New York Medical Journal" of January, 1859.

The subsulphate of iron, called by some the *persul-*

* See "Arch. Clin. Surg.," *ut supra*, pp. 96, 106, and 115; also "New York Med. Jour.," vol. xv, 1872, p. 175, "Successful Application of Dr. Speir's Artery-Constrictor," by Dr. Charles A. Hart; "New York Med. Record," March 1, 1873, p. 102, and March 15, 1873, "The Artery-Constrictor, with Cases," by Dr. Speir.

phate, powerfully constringes all the soft parts of the body with which it is brought into contact; it also promptly coagulates the blood; and it accomplishes both of these results, so valuable for the arrest of bleeding, without producing any escharotic or otherwise damaging effects upon the living tissues.

The subsulphate has replaced the *perchloride* of iron which had been introduced some years before by the French, mainly through the experiments of Pravaz, because the subsulphate *is equally powerful as a styptic*, and at the same time is entirely free from irritating qualities. The perchloride injected into the rectum and vagina has produced serious inflammation and sloughing (Després, "Nouv. Dict. de M. et C."). Nélaton speaks of its caustic power. This escharotic, astringent drug has its uses, but it is not a both powerful and harmless styptic, like the subsulphate of which I am now speaking; and, as they are not infrequently mistaken for each other, I desire to save you from this error.

The subsulphate of iron, unlike the perchloride, is entirely innocuous and unirritating. It is used in solution and in powder. The *liquor Ferri subsulphatis* of the U. S. Pharmacopœia, made to replace Monsel's solution, contains fifty-three per cent of the salt. I have dressed wounds—as after operating for fistula in ano—with the dried powder alone, and also with cotton-wool and with lint thoroughly impregnated with the powder. I have observed no escharotic effects in these cases; on the contrary, an undoubtedly benign influence in gently stimulating the healing process. I have blown the dried powder through a tube into the cavity of an abscess to stop bleeding. On one occasion, where I had made a thorough crucial incision of a large boil which was followed by protracted oozing (the patient being affected with the hæmorrhagic diathesis), I dried out the bleeding cavity and filled it in with the pure dried subsulphate; the result was a hard, black crust

or scab, under which the ulcer contracted down and healed with unusual rapidity.

The subsulphate, in contact with fresh blood, produces an intensely brownish-black, dirty-looking coagulum, which stains the fingers and towels and recalls the appearance produced by some caustics; but this is its only bad quality.

The best mode of applying the subsulphate in solution to an oozing cavity is by saturating little pledgets of cotton, or lint, or fragments of sponge with the solution, and then squeezing them dry as possible and packing them in contact with the bleeding surface.

Ordinary cotton-wool thus saturated and afterward dried makes an excellent styptic dressing to be kept always on hand. A preparation of this kind offers not only the hæmostatic virtue of the subsulphate of iron, but also that possessed by *all minutely divided substances*, of aiding—by this quality alone of minute subdivision, by which an infinite number of separate points of contact are presented to the blood as it flows—in hastening coagulation. Flint says: "If blood as it flows be received on a cloth, or on a bundle of twigs, it coagulates almost instantly." This explains the hæmostatic virtue of all the remedies, domestic and otherwise, which possess this quality of minute subdivision, such as cobweb, punk, a pinch of fur from a hat, and all the dry absorbent powders, some of which are also astringents. I have already mentioned parched rye-flour, applied by means of an ordinary dredging-box, as a favorite remedy of the late Valentine Mott for secondary oozing from a stump. I have used also in this way the dry subsulphate of iron, rubbed up with double its weight of powder of lycopodium, for dusting upon cancerous ulcerations liable to bleed—as of fungus hæmatodes, and also in other forms as a dressing for chancroids, and also for weak, profusely suppurating sores.

Under the head of styptics we include *cold*, which

has the effect of constringing arteries, veins, capillaries, and all the tissues by which they are surrounded, and also of diminishing the flow of blood toward a part to which it is applied. Cold also directly favors coagulation of blood; hence its popular reputation as a remedy for bleeding.

Its mode of action differs according to its degree. Carried toward the freezing point, after more or less pain, it first destroys the sensibility and then suspends the circulation in the part to which it is applied. A mass of carbonic-acid gas, solidified under pressure in Thallorier's apparatus, represents a still greater degree of cold. I have seen it, when applied to the skin, produce an eschar almost as promptly as a red-hot iron.

Cold may be applied in a moderate degree as a remedy by means of an evaporating lotion, ether spray, iced water, freezing mixtures, or ice in bulk; and very conveniently by filling a prepared pig's bladder one third full of small fragments of ice and tying its orifice. An ice-bag of this kind can be accurately molded to an irregular surface.

It must not be forgotten that there is always a possibility of danger from the prolonged application of cold. I have seen the edges of a wound of the scrotum slough from too long contact of the ice-bag employed to arrest a tendency to ooze.

Cold may be applied by means of injections of iced water into the rectum, vagina, or bladder. To such injections the subsulphate of iron might be added. In internal hæmorrhages we administer cold drinks by preference, and we keep the patient cool.

Heat, in the form of the actual cautery, was formerly the great remedy for controlling arterial hæmorrhage before the ligature came into use.

Applied in a moderate degree, as by means of a hot poultice or fomentation, it promotes bleeding by inviting blood to a part; but, when brought in contact with the tissues by means of a red-hot iron, the part touched

is instantaneously crisped and contracted into a hard, solid eschar, which effectually obliterates the orifice of any bleeding vessel included in it.

Formerly, cautery-irons, of large size and various forms, were in use. Now, we require but a few rather delicate needles for vascular tumors, and small button-headed irons. The very ingenious little apparatus known as the thermo-cautery of Paquelin, or the benzine cautery, at present meets most of the surgeon's wants in the most convenient manner. By the great facility of its application we are enabled to make deep incisions in vascular parts by means of the red-hot scalpel, and thus avoid hæmorrhage. I have employed it with great satisfaction in operations on the rectum, and elsewhere.

In the absence of this excellent contrivance an alcohol blow-pipe, or even an Argand burner in an alcohol lamp, are the best substitutes.

A cherry-red heat is the best for arresting bleeding. Iron at a white heat causes less pain, but it cuts through the tissues like a knife without crisping them sufficiently to prevent a flow of blood. This is illustrated by the action of the galvano-cautery devised by Middeldorpf, in which a wire attached at either end to the poles of a battery is carried around the part to be removed. When the elements of the battery are set in action the intensity of the current raises the wire at once to a white heat, and then it can be carried through the soft parts of the body as rapidly as a cutting instrument; but the blood flows about as promptly and freely as if an ordinary scalpel had been employed. On the other hand, a cautery-iron at a dull red heat crisps the tissues subjected to its action, at once, into a yellowish-black, horny eschar—hard outside but soft within—in which they are shrunk to one half their previous volume.

The cautery applied to the open end of an artery curls its several tunics inward upon themselves, so as

to seal it at once by a solid and strongly adherent stopper. Its effect extends for a line or two beyond the part actually touched by the cautery, and the surrounding tissues are puckered toward the burned point as to a depressed center. From the fifth to the eighth day after the application of the actual cautery the resulting eschar detaches itself, leaving a healthy granulating ulcer which is disposed to heal promptly.

It is thought that the surfaces left after contact of the actual cautery are less apt than other suppurating wounds to take on unhealthy action. This may be due to the solid barrier formed at once by the cautery, between the actually burned surface and the healthy parts beneath it, by the prompt plugging of its vessels for a line or two beyond the eschar; or, as has been suggested, it may be due to the contact of the animal charcoal—the charred animal tissues; charcoal, when freshly burned, being powerfully antiseptic. It has seemed to me to be true, whatever may be the explanation, that the phenomena that follow traumatism of this kind do not transcend the limits of the process of repair, and are very rarely complicated by unhealthy inflammation.

Before applying the heated iron, the part should be dried, at least partially, by cloth or sponge; the intervention of blood, or coagulum, or a moist surface, would interfere with its full effect. The cautery-iron should be touched lightly upon the part to be cauterized, if necessary, several times, but it should not be held in contact with the tissues; otherwise a portion of the burnt tissue might adhere to the cautery-iron, and possibly come away with it.

Among the ordinary chemical caustics, by which "potential," not "actual," cautery is effected, both *nitric acid* and *chloride of zinc*—if a surface can be rendered sufficiently dry for their effectual application—will produce an eschar by which hæmorrhage may be effectually stopped, not to recur *if the surgeon*

will patiently await the period of its natural separation.

The French mix the chloride of zinc, which is a deliquescent salt, with flour, and roll the compound into pointed pencils which they call *flèches*, and thrust one of these into the tissues at the point where its action is required. They also rank the *perchloride of iron* as an escharotic, and as the most valuable of the escharotics where hæmorrhage is to be managed. As I have already said, that typical styptic—the subsulphate of iron—although it simulates the behavior of an escharotic, is not even irritating to the living tissues; as a remedy to arrest hæmorrhage, it is a safer if not a more efficient application than the perchloride.

There are other substances which have a popular reputation for power to stop bleeding, but most of them owe their virtue to pressure, rest, the accuracy and care with which they are applied and held in contact with the bleeding surface, and to other obvious causes already explained.

Perhaps solutions containing *creosote* should be mentioned as having some value. Soot, which has a popular reputation for stopping bleeding, owes it probably to the creosote it contains. Billroth speaks favorably of the *essence of turpentine*, which succeeded with him in a critical case. He gives such a graphic account of this case that I am tempted to repeat it.

A young and delicate woman had been suffering for several months from a broken breast following confinement, and the suppuration still continued profuse from a deep cavity behind the mammary gland, lying between it and the *fascia* of the pectoralis muscle. Several incisions already made had failed to drain this cavity, and were closing, so that one day Billroth undertook a still deeper incision, and from the bottom of this there came a very free gush of blood. The incision penetrated the suppurating cavity, and was so deep that he was unable to get at the bleeding vessel, and

the blood still continued to flow freely. The cavity was thereupon stuffed with lint, and a compressing bandage applied; but the blood soon saturated this dressing, and escaped externally, so that he removed it, and injected iced water into the different openings. This seemed to moderate the flow, the compress and bandage were reapplied, and the hæmorrhage was apparently controlled. But he had hardly returned to his apartment in the hospital before he was recalled by the nurse because the blood was again escaping freely through the dressings; the patient had fainted, and he found her as pale as a corpse, with a hardly perceptible pulse. The dressing was again removed, and fragments of ice inserted into the bleeding cavity, but without effect; the flow continued as profusely as ever. "The patient went from one fainting turn to another, the bed was saturated with blood and ice-water, and the woman lay stretched before me insensible, with upturned eyes and cold extremities, the attendants striving to resuscitate her by holding ammonia to the nose and bathing her forehead with cologne-water. I, just beginning as a surgeon, never having witnessed such a scene before, had neither the coolness nor self-possession that comes from habit, and I was in a state of mind that I never shall forget. I had already the half-formed intention of rapidly amputating the breast so that I might get at the bleeding vessel and tie it, when the idea occurred to me to try the spirits of turpentine, which I had heard praised by one of my teachers. I forthwith saturated some pledgets of lint with turpentine and passed them down deeply into the bleeding cavity, when almost immediately the hæmorrhage ceased." The patient was now soon revived.

A smart reaction took place subsequently in the cavity of the abscess from the stimulating action of the turpentine, and a healthy growth of granulations followed, by which its cavity was in a short time entirely consolidated, and the patient made a good recovery.

Billroth adds that ever since this brilliant and unexpected result he has preserved a pious regard for spirits of turpentine as a hæmostatic, but he has no idea as to the mechanism of its action.

In connection with the claims of popular styptics it is well to know that bleeding from large vessels is much more readily controlled in the lower animals—through the greater activity of the natural hæmostatics in them—than in man ; and that styptics of mysterious pretensions might succeed in stopping the bleeding from the wounded carotid of a sheep which in the human subject would yield only to the ligature. But these styptics are more thought of popularly than they are used by the surgeon, who for the most part resorts at once to the unfailing remedy with which he is more familiar.

CHAPTER V.

Healing of wounds—The third indication of treatment—Plaster—Compress and bandage—Rest—Position—Sutures.

WE have now examined carefully the several phenomena presented by an incised wound—namely, pain, gaping, and hæmorrhage—and studied them in a general way as present in all wounds; and, because of its great importance, we have given especial attention to the subject of hæmorrhage.

In order to approach the subject of treatment intelligently, *we have next to consider the mechanism of the process by which an incised wound heals—for the object and end of all treatment is to favor this natural process.*

In former days it was the ordinary habit of speech to assume that a wound is *healed by the surgeon and his appliances.* Hence you read in old books of healing ointments and drugs to which wonderful powers were ascribed. *Now we recognize that it is by the power of nature that wounds heal—the same power, in another phase, that presides over the processes of ordinary normal nutrition, growth, and development—and that the main duty of the surgeon is to comprehend, as far as he can, the natural processes, and to see that they have fair scope.*

The rise and progress of correct ideas on this subject dates back only to the seventeenth century, and is curiously connected with the name of Sir Kenelm Digby, who lived in 1640, a philosopher possessed of knowledge beyond his time. Recognizing the absurd and

exaggerated qualities attributed to medicinal applications, and the stupid, painful, cumbersome, and officious modes of dressing wounds in his day, Digby professed to have discovered a new and wonderful remedy to take their place. This was his celebrated "*sympathetic powder.*" It was to be applied, not to the wound, but to the weapon with which the injury had been inflicted, the wound itself being left without any dressing whatever.

The wonderful success that followed Digby's new method of cure showed very clearly the injurious effects of the treatment previously employed for wounds, and the extent of nature's resources when not balked by interference.

Immediately succeeding the cessation of hæmorrhage in an incised wound, in fact, nature's efforts at healing will be found to have already come into play. As soon as the blood has ceased to flow, an oozing of almost colorless *liquor sanguinis* invariably follows in every incised wound. This watery discharge promptly glazes the raw surfaces with a varnish-like layer of a substance known in surgical pathology as *plastic lymph.*

The object of this oozing of coagulable material is to form the bed in which cell-growth is about to begin. It is unnecessary to tell you that all the tissues take their origin in cells. This particular cell-growth has for its object the formation of new tissue, known as cicatricial tissue, developed with the especial purpose of binding the severed surfaces once more together.

If the surfaces of an incised wound thus glazed by plastic lymph, and with no foreign matter intervening, were to be accurately placed in contact and held together by continuous, firm, and gentle pressure, they would coalesce and grow together, by the vital process I have just mentioned, in the course of a few hours. A delicate layer of the organized connective substance called cicatricial tissue, the product of cell-growth, which had taken place in the layer of plastic lymph,

would form the bond of union—and this process is called primary adhesion, or *union by the first intention.*

Microscopic inspection in the several stages of this process, in experiments on animals, has taught us these facts.

On the other hand, if the raw surfaces coated by plastic lymph should not be brought together, but should be left undisturbed, they would soon change their aspect and take on, in a day or two, that of suppuration and granulation. The suppurating surface would then tend to gradually contract and skin over, and present finally, sooner or later, a healed scar. This is what is known as the healing of wounds by the way of suppuration, or by "*the second intention.*"

When there is no foreign material on the surfaces of a recent wound to interfere with union by the first intention, it is the surgeon's duty to bring the surfaces together, and thus endeavor to secure this result, which, for reasons you will gather hereafter, is a result very much to be desired.

It is thus obvious why the indications for the treatment of wounds are laid down in most text-books as including these three conditions: viz., to stop bleeding, to remove foreign bodies, and to bring the surfaces of the wound together and keep them so.

When it has proved difficult or impossible to get rid of foreign matter between the raw surfaces of a wound, and primary union consequently fails, the foreign material is sooner or later detached, and removed, more or less perfectly, by the *suppuration* that follows. It was formerly regarded as one of the uses of pus thus to cleanse a wound, and means were employed to promote a flow of pus for this purpose. As we shall see hereafter, there would seem to be apparent reason in this view, and yet it is not held at the present day. The modern surgeon avoids suppuration as an evil, and for the most part does all in his power to prevent it. When, however, suppuration has proved unavoidable,

and a wound has thus cleansed itself, or when primary adhesion has failed from any other cause, it will be found, after a time, presenting a soft, granular, pinkish-red surface, and yielding a moderate flow of pus; this is called in surgical language a suppurating or granulating surface. From the nature of these granulations, which seem to have grown up for the sole purpose of accomplishing the healing process, it has been found that granulating surfaces, when the granulations are healthy and the surfaces uniform, will unite and coalesce if pressed gently together and kept quietly in contact with each other, with moderate firmness, for twenty-four hours.

This, then, is a third method by which healing may take place in an incised wound. It is neither union by the first intention—what we have called primary adhesion or quick union—nor union by the second intention by the slow process of suppuration, granulation, and cicatrization; but it is union by *secondary adhesion of granulations.*

It is necessary to keep these three modes of union of an incised wound clearly in the mind as covering nature's methods of repairing external incisions. Indeed, it is already obvious that the surgeon, by taking advantage of this knowledge of the adhesiveness of granulations, may very much shorten the period of healing of a suppurating wound by using means to bring its granulating surfaces together and promote their adhesion.

The best means of accomplishing this result will be detailed in connection with the *third indication* of treatment—viz., *to bring the surfaces of a wound together and to keep them gently and firmly in quiet contact*—the consideration of which will next occupy our attention.

For the purpose of maintaining wounded or granulating surfaces in contact, we employ *adhesive plasters, sutures, the compress and bandage*, and, when neces-

sary, *splints* or other apparatus by which support, in the best *position*, and *rest*, as absolute as possible, may be secured for the wounded part. Concerning each of these *means of retention* it will be necessary to say a word, for they are valuable weapons of the surgeon, and he must be familiar with them.

There is no better retentive material for the surgeon's purpose than the *emplastrum plumbi* of the United States Pharmacopœia—the ordinary adhesive plaster. This substance forms an almost indispensable portion of every retentive apparatus and of every variety of plaster. It was formerly called diachylon, and is, in fact, a chemical salt resulting from the reaction of the acids of fat upon one of the oxides of lead known popularly as litharge. It has been supposed to possess essential healing qualities, but these reside only in its unirritating nature, and in its power by its adhesiveness to keep parts quietly in contact.

Spread by machinery upon cotton cloth, and modified slightly to meet the necessities of climate, adhesive plaster will be found ready to the surgeon's hand in any part of the civilized world. Since the American method of making extension in fractures and in joint diseases has come into general use, adhesive plaster is spread upon thicker and stronger cloth for this especial purpose. Ordinary good plaster cut lengthwise of the cloth *will not stretch*, and it possesses a good degree of strength. As a rule, it gives rise to little or no irritation of the skin, even after prolonged contact. The bad effects sometimes attributed to the plaster are mostly due to the mechanical violence exerted upon the part by compression or traction, and the chemical irritation arising from the retained secretion of the sweat-glands.

For use, adhesive plaster is cut into strips, preferably lengthwise of the cloth; and, before being applied, it should be slightly warmed, when it adheres at once. Thus, if one end of a strip of plaster be applied upon

one side of an incised wound, after a moment's pressure by the hand to secure its perfect contact with the skin, a sufficient degree of traction may be made upon the other end to enable the surgeon to bring the opposed edges of the wound into accurate contact, and to attach the strip with equal firmness upon its opposite side. The proper method of warming adhesive plaster is to apply its cloth side momentarily to the surface of a bright tin vessel containing hot water.

Old plaster loses its adhesive quality through spontaneous development of fatty matter upon its surface. If it be brushed over, just before it is applied, with a little ether, chloroform, essence of turpentine, benzine, or any prompt solvent of fat, its adhesiveness will be at once restored. The same substances will also remove any of the plaster that may subsequently remain adherent to the skin. By their aid, and the use of warm water and soap to remove irritating discharges before renewing the dressing of wounds, excoriation of the skin can be almost always avoided. The plaster itself is rarely at fault. As lead-plaster is not soluble in water, the liquid discharges escaping from a wound do not readily loosen its hold upon the skin; and it resists the prolonged application of water for cleansing purposes, which, by saturating the tissue of the cloth upon which it is spread, will often allow this to be peeled off, while the material proper of the plaster remains adherent to the skin. Hence lead-plaster will retain its hold upon the margins of a wound for a time, even under the use of a poultice or a water dressing.

This can not be said of the *isinglass-plaster*, by which the celebrated Liston endeavored, some twenty-five years ago, to supersede the use of lead-plaster for dressing wounds. Isinglass-plaster is nothing more than the ordinary "court-plaster"—which owes its adhesive properties to fish-glue, the *ichthyocolla* of the Pharmacopœia, the popular name of which is *isinglass*. To make court-plaster, a strong solution of this sub-

stance is spread upon silk and dried. Liston claimed that this preparation is less irritating to the skin than lead-plaster. But the latter, as made at the present day, can hardly be called irritating. Its too great solubility in water renders the isinglass-plaster untrustworthy, and, for this reason mainly, it has not supplanted the adhesive plaster of lead, for many of the multifarious uses of which it can not be employed. More accurate coaptation of the edges of small cuts can be effected by its use than by lead-plaster, for it can be made transparent. For this reason, in wounds of the face and in some plastic operations, it has value.

Collodion, the well-known solution of gun-cotton in ether, is, in some cases, a useful substitute for adhesive plaster. When applied with a camel's-hair pencil over the closed edges of a small wound, it dries in a few seconds, leaving an adherent, translucent film, which, as it forms, contracts decidedly. This quality adds to its retentive power a slight capacity for compression.

A dressing of collodion retains its hold upon the skin fairly and resists the action of water, peeling off slowly as the outer layers of the epidermis detach themselves. If frequently applied to the same part, irritation of the skin is likely to occur at the edges of the adherent film of collodion, in consequence of the traction and puckering it exerts upon the surrounding integument. This contractile quality of collodion is done away with by the addition of one part of castor-oil to two of the collodion—the formula for the "liquid cuticle" employed at the King's College Hospital of London as a dressing for burns. It is equally transparent, and more tough and flexible than the pure collodion. The preparation known as Squibb's liquid cuticle possesses this quality.

For larger wounds, some surgeons prefer to saturate strips of some light textile fabric like gauze, or the material known as "tarlatan," in collodion, and to apply this across their edges, afterward applying more of the

collodion with a brush if required. This dressing is more or less transparent. Ice or iced-water may be applied over wounds dressed in this manner. It must be added, however, that there is danger that the liquid glue employed in this way may insinuate itself between the edges of the wound, and, by its presence and irritating quality, may sometimes endanger the success of prompt adhesion. It is also well to remember that, when applied to the scrotum, collodion causes very acute smarting.

Of all the surgical appliances for securing equable pressure, support, and immobility in the treatment of wounds and injuries, the *compress and bandage* are the most generally employed. We have already recognized their usefulness in applying pressure in hæmorrhage. Popularly, there is no useful surgical remedy more constantly abused. The surgeon sees a wound for the first time almost invariably enveloped by some sort of a bandage, for the popular mind recognizes, in a vague way, its value in stanching bleeding and in preventing wounds from gaping. But a bandage is usually applied in such a way as to defeat its object; most generally by constricting a limb in an uneven and irregular manner, by keeping the wounded part too warm, by exciting friction, or by adhering to a raw surface so as to render its removal an additional source of injury. Here there is necessity for art.

The dexterous handling of a bandage, and a clear idea of the uses to which compresses may be applied, are no unimportant elements in a surgeon's training. Bandaging is treated of in works on operative surgery under the preliminary title of "minor surgery"—an unfortunate designation of so necessary an accomplishment if it should perchance convey to a beginner the erroneous idea that this sort of skill is, in any sense, of minor importance. Few surgical dressings are complete without the final application of a bandage in some shape, and the dexterity acquired by training must be

supplemented by knowing why as well as how bandages are applied, or the result of an otherwise brilliant operation may be endangered. In fact, it is usually not so much the brilliancy of an operation as the patient care and skill in dressing the wound left afterward, and in the whole after-treatment of the case, which command a successful result.

I once knew an otherwise worthy surgeon fatally criticised at his first clinical lecture because he applied a bandage to the fore-arm in a fracture of the shaft of the radius before putting on the splints. This, you probably know, was an error, because the bandage necessarily pressed the fragments of the radius against the ulna, favoring the very deformity which belongs to this fracture—a deformity that is best obviated by placing a graduated compress lengthwise in the intermuscular space, with the splint immediately over it, both to be held in place by broad strips of adhesive plaster.

The best material in our country for bandages is stout, unbleached cotton cloth—what is usually called "sheeting"—showing a uniform round thread and a close, not a flimsy, texture. A more loosely woven material tends to gather into a cord, and to injuriously constrict the part to which it is applied. More uniform pressure can generally be effected by a bandage of flannel in unskillful hands, where the use of this material is admissible, for it possesses a much greater amount of elasticity. Bandages of stout, coarse linen, what we should call canvas or duck, are used in the French hospitals, but these are too costly for us, and tend to slip too readily; they are inferior to bandages of stout American cotton cloth.

The quilting-in of pins, or the use of a needle and thread to fix the turns and folds of a bandage in their places after its application, are very useful, except where the whole can be saturated with dextrine, starch, or plaster of Paris.

It is always to be borne in mind that *uniform and equable pressure is the end sought for* in applying a bandage; and that just in proportion as it cuts or constricts a part unequally, it is useless or positively injurious. Thus, for keeping pledgets or compresses in position upon a bleeding vessel, or for making pressure upon a bubo; for assisting strips of adhesive plaster and sutures in maintaining the edges of a wound in accurate contact; for holding the dressings in place upon an open wound or ulcer; or for retaining pads and splints in exact position over the fragments of a broken bone—anything like irregular or uneven constriction, or the absence even of uniform and equable smoothness and pressure, would constitute a radical defect in a dressing.

When the fold of a bandage seems to constrict too much any particular part, a spatula, or the handle of a tablespoon, inserted between the folds and slightly rotated is about the best device for loosening it up and rendering the pressure more generally equable. Where it is necessary to bandage a limb systematically from the fingers or toes upward, the surgeon should always satisfy himself afterward that the radial or plantar artery is pulsating, and that the capillary circulation in the fingers and toes is really going on. This should be repeated from time to time, for a very slight increase of swelling of a bandaged limb might lead to stoppage of its circulation, even to the extent of causing gangrene. I have known this to happen, even in young subjects, and in an upper extremity, in more than one instance. Prepared wool should also be carefully placed around the malleoli or other projecting points of bone, to protect them from the disproportionate pressure they would otherwise receive from a bandage, which, without this precaution, might cause eschars. Wool is better than cotton, on account of its elasticity.

A compress, made of any soft and elastic material, should be so shaped and applied as to bring the press-

ure of a bandage to bear upon any part desired, for the purpose of supporting and holding together the deeper portions of a wound, or the walls of an abscess after its contents have been discharged, or the walls of a sinus so as to secure adhesion of granulations, or for controlling a tendency to deformity in fracture.

The capacity of the soft tissues of the body to bear pressure without danger of losing their vitality is always to be kept in view in using compresses and bandages. This is only to be learned by experience, and varies in different individuals. It is not a judicious practice to give an anodyne to quiet pain caused by a bandage, for pain is a useful guide as to the degree of pressure that can be safely borne. I am still considering the means at the surgeon's command to fulfill the third indication in the treatment of wounds so as to secure their prompt healing.

For securing *absolute rest and quietness* in a wounded part, *splints* of some unyielding material are very often indispensable—as, for example, when a wound is situated near a joint. After the raw surfaces have been placed in apposition, there is no consideration more essential than this to favor rapid and certain healing; and no point in the treatment of wounds is more frequently neglected than the use of adequate means to secure the immobility so necessary for healing. *There is little use in ordering a patient to keep an injured part quiet;* unless motion causes acute pain the order will not be obeyed, and failure in prompt and perfect healing will follow. The surgeon is responsible for this failure, for he has the means at his command of enforcing immobility. These means are splints and bandages, or apparatus contrived so as to replace them more perfectly. We are familiar with the pain and festering and protracted soreness that so often follow a simple abrasion of the skin over a knuckle. Popularly this festering and refusal to heal is ascribed to "bad blood," or to "taking cold" in the

part; but it is really due in a great degree to the constant dragging upon the stiffened and injured skin by the motions of the joint, which render the healing process slow or impossible. But we are not so familiar, perhaps, with the fact, which proves this statement, that a splint of unyielding material applied along the flexor aspect of the joint, and kept firmly in its place by strips of plaster so as to immobilize the articulation, will be followed almost certainly by immediate freedom from pain and progressive healthy healing. Many a mechanic has been laid up for months with a "bad" hand, taking its origin in an abrasion, trifling at first, of a knuckle, which might have been cured in a day or two by this simple precaution.

I once saved a limb, and probably a life, in a gentleman brought to the city with a wound from a pistol bullet in the knee, by fixing the limb so immovably to an inclined plane that absolute quiescence was secured. The limb was condemned by a consultation which I had thought proper to summon, but, contrary to the prognosis, the patient got well; and I ascribed this gratifying result to the absolute immobility and free and repeated application of leeches.

The "wire breeches" employed by my colleague Dr. Sayre after his operations for exsection of the head of the femur contribute to their remarkable success, in my judgment, by the perfect rest they secure to the parts involved in the operation.

Splints may be made of any materials combining the requisite qualities of lightness and strength: such, for example, as wood, carved or plain; tin; wire; sole-leather, or gutta-percha. Or of bandages alone, rendered stiff and unyielding by dextrine, starch, silicate of soda, or plaster, with windows cut to afford access to the wound.

Guérin, surgeon of the Hôtel Dieu of Paris, claims unprecedented success in the treatment of stumps after amputation by enveloping them abundantly with cot-

ton wadding, which, by its elasticity, allows bandages to be applied over it as tightly as the dresser's strength will allow, and these produce no unpleasant constriction of the limb. In addition to immobility and security from external violence, this dressing of cotton-wool affords equable pressure upon all parts to which it is applied, and keeps them at an unvarying temperature, without mentioning the *antiseptic* virtues attributed to it, of which I have yet to speak. This mode of dressing is admirably adapted to the emergencies of military surgery, where patients after amputation are subjected to transportation in ambulances.

The *position* in which a wounded or injured part should be maintained, after it has been dressed, is a matter of importance, and should be carefully considered. The main points are—to favor return of blood from the injured part, and guard against sanguineous congestion; to avoid muscular tension and consequent twitching by placing the nearest joint as nearly as possible in a position midway between flexion and extension; and to prevent traction or interference with the retentive dressing. Thus, antero-posterior rather than lateral incisions are preferred for flap amputations in the lower extremity, and the stump is raised to an angle of forty-five degrees by cushion or pad, or it may be suspended, through the intervention of adhesive plaster, from some point above. The leg may be elevated and similarly suspended, hammock-wise, as in Salter's apparatus, which is used in treating fractures at sea; and thus both advantageous position and greater freedom from motion at the seat of fracture are attained.

In Professor Hodgen's modification of Nathan R. Smith's dorsal splint for fractures of the thigh, traction is made by an ingenious adaptation of the pulley and weight to the broken bone in the semi-flexed position of the hip-joint. I have seen this excellent American device in use in the wards of Guy's Hospital in Lon-

don. Bryant has a wood-cut of it in his Manual, and praises it.

In a transverse wound of the calf of the leg, as made by a scythe, both extreme flexion of the leg upon the thigh, and also extreme extension of the foot upon the leg, are required to aid by position the retentive means employed to approximate the surfaces of this very awkward wound. In rupture of the tendo Achillis the same result is sought for in relaxing the enormous muscles of the calf by forced extension of the foot by means of a simple apparatus.

Surgical *sutures* constitute an important element in the retentive apparatus employed in closing wounds.

A *suture* is a strand of silk, or wire, or prepared catgut, inserted through the edges of a wound, generally by means of a needle, and knotted, clamped, or twisted at its ends, so as to secure firm and accurate apposition of the raw surfaces. Sutures should be adapted, in thickness and strength, to the size and depth of the wound, and the nature of the tissues to be held in contact. If they are larger than necessary, their presence occasions needless suppuration; in fact, they act like setons, and they are liable to leave unsightly scars.

To secure accurate and sure union of the edges of divided integument, as in some of the plastic operations, there is hardly a limit to the proximity of points of suture to each other, provided they are very fine and delicate, and care is taken to remove them early; but where it is the surgeon's object to keep the deeper surfaces of a large wound in contact, he uses stronger sutures, inserts them at a greater distance from each other—three quarters of an inch to an inch, for example—applies strips of adhesive plaster transversely between them, and possibly a compress and bandage besides.

In applying a ligature to an artery we draw the knot tightly, intending that it shall cut itself out

through the tissues as soon as possible, well knowing that the vessel will be obliterated some days before the ligature can possibly separate. In applying sutures to a wound, this rule is reversed; we desire them to hold parts together as long as possible without cutting out, and are careful, therefore, not to draw them tightly lest they should cut out prematurely, and not only fail in their object, but leave unsightly scars behind them. Any degree of tension, therefore, as from prospective swelling, should be guarded against by the interposition of strips of adhesive plaster to prevent undue dragging on the sutures.

Wire, as already remarked, causes little or no suppuration by its contact with the tissues, but, in consequence of its greater comparative strength and its consequently smaller volume, it is more likely to cut itself out in case of much tension. Metallic sutures are especially useful in wounds involving mucous surfaces—as in the American operation for the cure of vesico-vaginal fistula—where plasters and other aids to retention are inapplicable, and where Sims gained his great triumph by their aid. In this operation the points of metallic suture are placed quite near together; clamps, split shot, and other devices are employed to prevent them from cutting out before their object has been attained; and here experience has taught the surgeon to watch closely for too much tension, and to judge how long they may be left.

The removal of a point of suture is best effected by insinuating the sharp point of a scissors-blade through the loop and snipping it, then seizing the knot and withdrawing the loop gently with the forceps. The proper time to do this is as soon as the object of the suture has been accomplished, generally in from two to five days—according to their size and the depth at which they have been placed—they may be left for even a longer period if union is of sufficient importance to justify the risk of scars.

When catgut is employed for sutures, they may be left to take care of themselves. Sutures cut out more rapidly in infancy and childhood than in adult or advanced life, and should therefore be removed earlier. The deeply placed pins in the operation for hare-lip in the infant a year old are removed in from two to four days, but when left to the latter period they may leave scars.

Some of the tissues are cut through more readily than others; thus, muscle and connective tissue give way sooner than tendon or fibro-cartilage. Wire sutures may be usefully applied to bone by using delicate drills for their introduction. I have in this way secured solid and early union between the sawn surfaces of the head of the tibia and the femur in excision of the knee-joint. Some force may be required for their removal. In my case there was no callus whatever, showing that the apposition was accurate and undisturbed.

The best *needles* for introducing sutures are those used by the glove-makers; they are triangular, and penetrate the skin more readily than needles with conical or flat points, which are apt to wedge awkwardly in the dense tissue of the skin, and require force in their introduction. Punctures made with lancet or spear-pointed needles, sharpened so as to make them pass readily, are liable to bleed unpleasantly, because these needles cut, which a triangular needle does not. *Glovers' needles*, then, are the best, and also the cheapest, straight needles for the surgeon.

Curved needles are only necessary in certain localities in the body—as in the vagina, rectum, soft palate, and where the alæ of the nose join the cheeks. They are better of small size, and they should represent, as a rule, an arc of a circle—*and of the same circle throughout their whole length;* otherwise they will not readily pass through the tissues. Curved needles are more conveniently managed by means of a needle-carrier made for the purpose. These needles are only required

for use in cavities, or where a straight needle can not be made to pass; elsewhere the straight needle is by far the more serviceable instrument. The point of a needle should always be dipped in vaseline to facilitate its passage.

Thus far I have spoken only of simple separate points of what is known technically as "interrupted" suture; but a thread of silk or catgut may be sewed over and over, closely uniting two borders of a wound like the seam of a glove; and this is the proper mode of treating certain wounds of the intestine or peritonæum. This is called the *uninterrupted* or *continued suture.*

There are several other varieties of the interrupted suture: e. g., where double threads are looped and knotted over pieces of quill or bougie, to keep the deeper surfaces of extensive incisions in accurate contact, a variety especially suitable for incised wounds of the abdominal walls, and known as the *quilled suture;* and the *clamp suture,* in which strands of wire are carried through perforated strips of metal and fastened by split shot, a device which has been found especially serviceable for rupture of the perinæum in the female.

Threads of silk or cotton are twisted in figure of 8 over the ends of needles or insect-pins which have been inserted deeply through the opposed edges of a wound, as of the scalp, where bleeding is free, or of the lip, where an epithelioma has been removed by a V-shaped incision; these constitute *the twisted suture.* You will see examples of these varieties of suture at the clinics.

There is a principle involved in the proper mode of applying the continued suture to wounds of the intestine, which was first brought into prominence by the French surgeon Dupuytren, namely, that the edges of the intestinal wound should always be turned or doubled *inward,* so as to bring peritonæum in contact with peritonæum by free surfaces before sewing them together over and over, for free surfaces of mucous

membrane can not be made to adhere promptly. If the ends of the thread, after the peritoneal surfaces have been sewed together by the continued suture, are then separately knotted so as to prevent slipping, they may be cut off close to the knots and the wounded bowel returned to the abdominal cavity, with a positive assurance that, if the patient survive, the thread, when it cuts out, will certainly fall into the cavity of the bowel and be ultimately passed at stool. It is promptly and effectually covered in by the plastic lymph which exudes from the wounded serous surfaces for the purpose of uniting them by primary adhesion. It is hardly necessary to repeat that primary adhesion between mucous surfaces can not be counted upon; nor primary adhesion between a mucous and a serous surface.

Now, gentlemen, many of the details with which I have been occupying your time may have seemed to you to be tediously minute; but my duty compels me to tell you that good surgery is largely made up of just such details as these which have occupied us. The surgical mind must be able to grapple with them, take them in, and apply them, with the same patient effort that is required to master the microscopic details of histology, and without this effort no man can be a good anatomist or physiologist, and without it no man can be a good surgeon.

The advance of our science and art seems to be mainly achieved, in modern times, by patient attention to details heretofore wrongly ignored in consequence of their minuteness. And this is true of chemistry, astronomy, and most other branches of natural science. It has been truly said, "*Deus maximus est in minimis*," i. e., the Deity is greatest in his minutest works. Formerly fatal epidemics were ascribed to earthquakes and great storms which had preceded them. Now, the best opinion as to the cause of cholera and yellow fever attributes these plagues to the presence of microscopic organisms whose germs float in the air; and it is be-

lieved that the best chance of escaping them lies in discovering the conditions of life of these invisible enemies, so that we may prevent their germination and development.

It is an instructive fact that Pasteur, of the French Academy, has apparently saved the immense silk trade of France by his discovery that the steadily spreading silk-worm disease was due to a microscopic parasite ingrafted upon the silk-worm race during its cultivation in France, which invaded even their eggs and threatened their entire extinction. This discovery was the result of years of patient microscopic research, and of ingeniously devised and closely observed experiment. It was proved in this way that the only escape from impending catastrophe was to be found in the wholesale importation of the uncontaminated eggs of a new and vigorous race of these insects from the prolific regions of the East; and this measure has been crowned with success.

One more word concerning sutures and I have done. There is a tradition still in force that sutures, especially when applied in the scalp, tend to cause erysipelas. I feel justified, after using them for forty years, in expressing the opinion that this is an error, and should be forgotten. Erysipelas, as I shall show you hereafter, is due to a special poison, probably, also, of the nature of microscopic vegetable fungoid germs, which assume active vitality only under certain circumstances which arise under the influence of defective hygiene.

The perpetuation of such errors as this tends to promote false issues, and therefore to obstruct the advance of scientific surgery.

To sum up the means at our command for approximating the edges of wounds and maintaining them in contact and in perfect rest in a favorable position for healing, we have plasters of lead, isinglass, and collodion; sutures of silk, wire, and catgut, interrupted and continued; bandages and compresses, with splints

and special devices of much variety. *It is worthy of note that none of these appliances possess any special healing virtues of their own. Their great value lies in the fact that they intelligently favor the efforts of nature.*

After an incised wound has healed under the treatment just described, by either of the methods of union indicated, a distinct, somewhat elevated red line will be left, marking, in some measure, the course of the incision. This line is the surface edge of the layer of new tissue by which the wound has become united. It is red, from the great number of the recently formed capillaries carrying red blood which it contains; but later it becomes white in color, even more so than the surrounding skin, because these new capillaries contract and disappear shortly after their work has been accomplished. For the same and similar reasons the scar loses its elevation, and becomes in the end more or less depressed. The line of cicatrix following primary adhesion may be very slight; in exceptional cases even barely perceptible; but *it is never entirely absent;* and, where cicatrization has been delayed, as in union by the second intention, attended by prolonged suppuration and possible interruption of the process of granulation, the resulting scar is often puckered and otherwise unsightly.

There are certain other modes by which wounds heal besides those which I have already indicated—modes of healing in which the retentive means which we have been studying are not so absolutely necessary, or are required only in a modified form. What I have to say concerning these methods will apply to injuries as well as wounds.

CHAPTER VI.

Other modes of healing—Scabbing—Histology of the process of repair.

The first of these modes of healing is scabbing, or healing under a scab or crust. It occurs spontaneously, under favorable circumstances, in simple abrasions or wounds with little depth, and in the milder degrees of surface burns. This is the most natural and simple of all the methods by which healing takes place. It is the mode by which most of the surface wounds and injuries of the lower animals are repaired. Most animals lick their hurts, and in this way remove foreign matter from them. When hæmorrhage has ceased, the plastic lymph that coagulates on the surface of the hurt becomes dry by exposure to the air, and is mingled with more or less blood. Or, if suppuration has taken place of necessity, the same result is arrived at by drying of the pus. Beneath the crust or scab, however, plastic lymph accumulates by exudation from the wound's surface, and in the plastic lymph, as I have already said, cell-growth begins. If the process of cell-growth is not interrupted by new violence, it goes on steadily and quietly to the formation of new tissue, and in a little time a well-formed scar will have taken the place of the wound.

When this process of healing under a scab goes on without accident or interference the scab falls spontaneously as soon as the newly formed cicatricial surface has become invested with epidermis—i. e., when the process has completed itself, and not till then. *By the regular growth and formation of successive layers of*

epidermis beneath it the scab is literally pushed off. It is wrong to try to hasten this event by detaching a crust prematurely, no matter how dry it may be; it will certainly take place spontaneously when the proper time has arrived. The wise surgeon waits till Nature completes her work in her own way, and he waits patiently, knowing that in this way she works better than he can. The surface of a scar thus formed beneath a crust *is more smooth and perfect, and more closely resembles ordinary integument*, than any other kind of scar. When the crust has been prematurely detached, the scar is more likely to show irregularities.

We see illustrations of this mode of healing in abrasions from falls on the face, and here the appearance of the injured part a day or two after the accident may be quite frightful and suggestive of a much more severe injury than that which really exists. The crusts are discolored by dried blood, and are thicker and more unsightly from this circumstance, and the temptation to remove them, on the plea of exploring the extent of the injury beneath, is somewhat urgent, and very apt to coincide with the wishes of the patient and of the patient's friends. But, for the reasons I have just given, it is usually unwise to yield to this temptation. If nature has taken the cure in hand, and the crusts remain dry, it is wiser to leave them untouched, no matter how hideous their appearance, even if there is a good deal of swelling. By this sign—i. e., the dryness of the crusts—you may know that interference is contra-indicated.

On the other hand, if nature can not carry out the process, suppuration will certainly take place at some point. The event will be recognized by complaint of unusual tenderness at the point, and the oozing of a drop or so of pus on slight pressure. Unless these symptoms are very trivial, it may become advisable in such event to remove the crusts and replace them by a simple ointment or a water dressing. The application

of the latter, or of a poultice, is the best way to get rid of scabs without causing irritation. A little glycerin is a good addition to a lotion or poultice. This useful substance never dries by evaporation, and it is antiseptic, arresting putrefactive fermentation; but, used too freely or undiluted, it may cause smarting and irritation.

A good lotion for water dressing under these circumstances would be made by adding ʒ ij of simple borax and ʒ iij of glycerin to Oj of water, or ʒ j of boracic acid with ʒ ij of glycerin to Oj, or ʒ j of carbolic acid and ʒ ij of bicarbonate of soda to the same quantity of water. These lotions are more grateful to the patient's feelings if applied warm. Or ℥ j of sweet almond-oil rubbed up with ʒ j of balsam tolu might be applied with a camel's-hair pencil, and followed, after a time, by a poultice. The best poultice is made with slippery-elm flour, with a little glycerin added to prevent its drying at the edges.

At the temperature of the skin, pus and other discharges decompose quickly and give odor; hence the advantage of the antiseptic quality in the applications which I have suggested. The ordinary lotion of lead-water, useful as a sedative and astringent where the skin is unbroken, is decomposed by the sulphureted hydrogen given off by decaying matter, and leaves a dirty, black deposit of sulph-hydrate of lead. I may add that simple vaseline—the *ung. petrolei* of the Pharmacopœia, also an antiseptic, and unchangeable as to rancidity—is probably the best of the simple ointments. What you want in an ointment under these circumstances is simply to exclude the air and dust, and to give opportunity for the formation of a granulating surface and for healing by this latter mode. But I am free to say that healing under a crust or scab is always to be preferred whenever it is possibly attainable; and I venture again to warn you against officiousness, which in surgery is not a very rare fault, and often a

serious one. It is often committed in removing scabs which nature is wisely keeping in place. When it is in your power to choose between these modes of healing, always adopt the method of scabbing for simple abrasions.

Scabbing may *be favored* by exposure to the air, by dusting a moist surface with some very finely divided and absolutely unirritating powder, and by keeping the part perfectly still and quiet. The best powders are the simple oxide of zinc, oxide of zinc in combination with double its weight of powdered starch or rice-flour, or the powder of lycopodium of the United States Pharmacopœia.

As an interesting example of this method of healing, I may mention the device, credited to Sir Astley Cooper, of promptly closing the wound in a compound fracture, when of limited extent, by means of a pledget of lint saturated with blood, in the hope of its drying into a scab and thus converting the compound fracture into a simple one. There are English surgeons of the present day who advocate the systematic plan of dressing all possible wounds in such a way as to secure prompt closure and healing without suppuration by excluding the air with an artificially formed crust. Lint saturated with a substance called "styptic colloid," a preparation of collodion, is one of the dressings employed for this purpose. Pulverized dry earth has also been used with advantage. The dry dressings so highly praised by Mr. Gamgee in his recent papers in the London "Lancet" belong to this category. Cases are attributed to Wardrop and to Henry Lee, well-known English surgeons, in which large wounds, left after the removal of diseased breasts, healed entirely under crusts of dried blood and liquor sanguinis. In Wardrop's case the crust remained in place for more than thirty days.

Finally, the modern mode of dressing wounds by means of antiseptic gauze and the other appliances of

Lister is nothing more than a systematic device to secure healing under a crust by the aid of certain modifications in dressing. The results obtained by it demonstrate this; for wounds heal under the antiseptic dressing by simple cell-growth and development in a bed of plastic lymph, without a drop of pus. How far the antiseptic element contributes to this result, and what is the explanation of the great advantages which evidently belong to these methods of dressing, we will discuss at another time. For the present it is safe to assume that *the sealing up of the wounded parts more or less completely, and the consequent exclusion of air, is the factor of greatest importance.*

The truth of this assumption as to the advantages to be derived by the exclusion of air from healing wounds is based upon the fact that traumatisms in the interior of our bodies, away from the contact of air, when not necessarily mortal, and when there is no foreign matter to be eliminated, always heal without the formation of pus. We constantly see in the deadhouse well-formed scars in the liver, kidneys, and brain, following injuries which have for the most part passed unrecognized during life. The same mechanism of healing which I have already described in outline has taken place here, viz.: *the effusion of plastic lymph and its organization*, by cell-growth and development, into cicatricial tissue.

But the best illustration of the more rapid and safe healing that takes place when the air is excluded is witnessed in the wonderful success that follows *subcutaneous wounds*, as in the operation of tenotomy. Up to half a century ago wounds of tendons and similar white fibrous tissues were regarded by surgeons as exceptionally dangerous, they were almost certain to be followed by prolonged suppuration and other serious complications, and repair was not only tedious, but liable to be followed by deformity. In surgical operations, tendons as well as muscular aponeuroses were

consequently avoided; and, as you will infer, orthopædic surgery was almost unknown. A German surgeon named Stromeyer, of Hanover, about the year 1830, who had been impressed by the results of some experiments on horses, was led by his genius to an important discovery. He found that, when cut across beneath the skin by means of a slender needle-like knife, the puncture in the skin being immediately sealed so as to exclude the air from the deeper wound, the tendon of the horse, after a very little time, grew together again without pain, inflammation, or formation of pus. He was thus led, while striving to rectify the deformity in congenital club-foot and similar affections, to divide tendons subcutaneously in the human being; and he secured the same unexpected and brilliant results. By this discovery Stromeyer became the father of orthopædic surgery, which, by its numerous and successful applications, has added so much to the happiness of the human race and to the honor of surgery.

Sir James Paget afterward made a series of experiments to determine the exact difference in the healing of divided tendons by an open and by a subcutaneous wound, and he recounts one of his experiments, which will serve as a fair example of the results he obtained: "In the same rabbit the *tibialis anticus* and *extensor longus digitorum* were divided on the right side with a section through the skin, on the left with a subcutaneous section through a small opening. Twelve days afterward the rabbit was killed. The subcutaneous wound on the left side was well repaired, and with comparatively little trace of inflammation; the gap on the right side was closed in with a scab and an imperfect scar, but under these was a large collection of pus, and no trace of a reparative process." ("Surg. Path.," Philadelphia, 1871, p. 132.)

This illustrates a truth announced by John Hunter many years before; but the force and value of Hunter's statement had not been fully estimated nor practically

applied in a general way until after Stromeyer had divided tendons subcutaneously and secured union without suppuration. It may interest you to hear Hunter's original words. In his "Treatise on the Healing of Wounds and Injuries" (1792) he begins thus: "The injuries done to sound parts I shall divide into two sorts, according to the effects of the accident. The first kind consists of those in which the injured parts do not communicate externally—as concussions of the whole body or of particular parts, strains, bruises, and simple fractures, which form a large division. The second consists of those which have an external communication, comprehending wounds of all kinds, and compound fractures. . . . The injuries of the first division, in which the parts do not communicate externally," says Hunter, "seldom inflame, while those of the second commonly both inflame and suppurate." And here is Sir James Paget's commentary: "In these sentences Mr. Hunter has embodied the principle on which is founded the whole practice of subcutaneous surgery—a principle of which, indeed, it seems hardly possible to exaggerate the importance." You have here, gentlemen, a clear statement, and also a demonstration of its truth, both from the highest authorities, that wounds and injuries heal more rapidly and surely when they are cut off from exposure to the air. To keep this point, and the distinction it involves, clearly before the mind, the designation of "*open wounds*" and "*sealed wounds*" has come into general use.

Precisely in what manner exposure to the air acts injuriously in retarding the healing of wounds we can not discuss just yet, for this involves the theory of antiseptic dressings and Listerism, which will come under consideration later.

Meanwhile, however, we have arrived at a valid basis for *classification of the several modes of healing.* It may be said that *all wounds and injuries heal in four ways:* 1, *by primary or quick union* (*first in-*

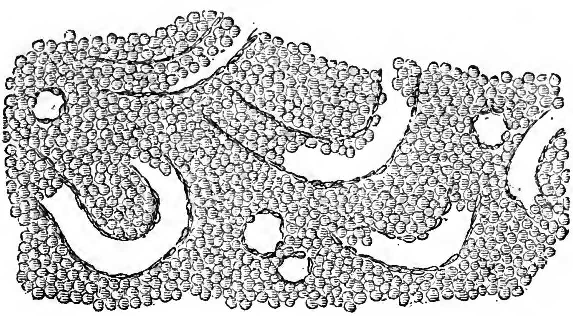
tention); 2, *by scabbing, and by subcutaneous consolidation—the mechanism in these being identical; in these two modes of healing the air is excluded; the wounds are sealed;* 3, *by granulation and suppuration* (*second intention*); 4, *by union of granulating surfaces* (*secondary adhesion*). *In the two latter the wounds are "open."*

It will be proper now to complete the details of the mechanism of these several processes, which it is the surgeon's duty to supervise; and, to supervise them intelligently, he must be familiar with them. I have already described them in a rapid way, but there are points in connection with each which require further elucidation. I have assumed, for example, that the main feature in each of these four ways of healing is the organization of plastic lymph, but a surgeon should know something more precise concerning the nature of "plastic lymph," and also what is meant by "organization."

According to Robin, *plastic lymph is a secretion from a freshly wounded surface, and its constituents are derived from the blood-plasma;* but, as distinctly held by this authority, *it is not blood-plasma,* nor does it contain fibrin, as such. When a portion of this adhesive, jelly-like substance—plastic lymph—is scraped from the surface of a recent wound and placed under a microscope, it is found to be a homogeneous material like that of which the human embryo consists when it first becomes recognizable. It contains molecular granules and some scattered red blood corpuscles, derived, probably, from adjacent capillary loops. The molecular granules, in which the formative power seems to reside, cluster themselves together to form nuclei, and around the nuclei cells form. As soon as they are formed the cells begin to proliferate rapidly—i. e., they increase and multiply—and in a very little time the lately gelatinous mass is found to be swarming with cells, so that it seems to consist of nothing else.

And now a strange phenomenon takes place: a minute stream of cells, slightly differing in appearance from the others, is seen coursing its way through the crowd of original cells, which seem to flatten out and make walls to keep the slender current within bounds; and this current assumes forthwith the outline of a loop. It is, in fact, a newly formed capillary, containing red-blood corpuscles. These latter may be recognized by their peculiar shape—that of biconcave disks, with which you are familiar. The drawing, which I

FIG. 4.



Granulation tissue. Magnified 300 diameters.

borrow from Billroth's "Surgical Pathology," very well represents the appearance of this mass of cells under a moderate magnifying power, with here and there a capillary loop, distinguishable by its color.

The cells of which this new formation is mainly composed are called by Huxley "embryonic" cells. He gives them this name because they are the first formed and most constant features that make their appearance in the jelly-like substance—the plastic lymph, if you will—that constitutes the human embryo when it first becomes recognizable under a magnifying power. These cells are almost, if not quite, identical with *white-blood corpuscles, with lymph corpuscles, with young pus-cells, with young epithelium, with granulation-cells, and with young connective-tissue corpuscles;*

and to all these cells, undistinguishable from each other by any means at present at our command, the name of "*leucocytes*" (which means, literally, *white cells*) is applied by histologists.

A leucocyte is nothing more than a mass of protoplasm containing some granules, and, under some circumstances, investing itself with a cell-wall. The granules, as I have already said, seem to represent its germinating force. Leucocytes are generally spherical in their outline, but they are very capable of changing their shape, and indeed they possess, in a certain degree, the power of locomotion. This may be verified without difficulty by carefully observing the behavior of young pus corpuscles under the microscope. The phenomenon of cell migration, as first observed by the Englishman Waller, and subsequently by Cohnheim, of Berlin, in 1867, in the white corpuscles of the blood, and since verified by all microscopists, is accomplished by the power of locomotion possessed by these curious bodies. They have even been detected with granules of vermilion in their interior after this substance had been injected into the blood-vessel of a frog, the granules having been evidently included by the soft masses and retained within them. A leucocyte would seem therefore to possess certain powers characteristic of individual life.

The power of thus changing its shape and locality was first observed in an organism, apparently identical with the leucocyte, that infests certain forms of decaying vegetable life, and known as the *amœba;* and this peculiar power is hence spoken of as *amœboid motion.* I have seen it in pus corpuscles voided from the bladder in vesical catarrh, but it is only seen in *young* pus corpuscles. When they become mature, they lose this curious quality.

This anatomical element, or individual organism, as it may be considered, is met with so constantly and in so many phases in surgical pathology that it is necessary that we should know something of it.

Now that the army of embryonic cells, or leucocytes, begotten by germination and proliferation in the bed of plastic lymph furnished by a recent wound, has furnished itself with a *basis of supply* of nutrient material through the newly channeled capillary loops, the individual cells next begin to develop; and their development, as I have already said, results ultimately in the formation of connective tissue.

The plastic lymph has thus *organized itself by establishing a vascular connection with the blood-supply of the body at large*, and it now forms an integral part of the organism. Capillary vessels pass from adjoining parts into it, and the blood is returned through newly formed capillaries that leave it. Its *organization* is therefore complete as far as vascular supply and continuation of life are concerned. This illustrates the meaning of the term *organization* as used in studying the principles of surgery; *it signifies, as regards a new formation, a common source of blood-supply with the rest of the body, and a consequent capacity to grow and develop.*

The phenomenon of the spontaneous generation of capillary vessels is, after cell-growth and development, the most remarkable of the ultimate manifestations of vital force. If this should fail, further cell-growth would cease, and, through lack of nutritive material, there would be no progressive structural development. It would seem to be a law that the nutritive material must always come, directly or indirectly, from the blood.

Histologists describe several methods in which capillaries in newly forming parts take their origin besides that by *channeling*, already described. They may be observed, in the transparent tissues of animals, under the microscope. Sir James Paget mentions and figures several methods he has witnessed.

Now, in regard to *connective tissue*, which is to be the issue of the effort at structural development which

we are considering, it is exceedingly desirable that, as surgeons, we should have a comprehensive idea of its nature and properties; *because this singular substance is pretty much the sole medium of union of all wounds, and the cicatricial substitute by which all losses of substance in our bodies are repaired.* In our complex organisms *it is almost the only one of our elementary tissues that may be said to be capable of reproduction;* hence its great usefulness in the process of repair of wounds and injuries.

In the lower organisms this power of repairing injuries is much greater than in ours, and all of their tissues and many of their organs can be reproduced when damaged or destroyed. In man the reparative power is confined within narrow limits, and it is *possessed only by this all-pervading and most useful of all our subordinate tissues*—that which we call *connective.*

As I have said, connective tissue, concerning which we can not know too much, is the earliest manifestation of structural development in the embryo. It first appears in the form of a *jelly-like mass*, containing leucocytes, under the name of embryonic cells; but this is a very different substance from the more fully formed, web-like tissue you are familiar with in the dissecting-room.

When mature, the office of fully formed connective tissue is (without restraining in any way their respective functions) *to hold the different organs of the body in their proper relation to each other.* Hence the significance of its name; and this significance extends also to its surgical uses. Thus, it surrounds and envelops every capillary, vein, and artery in the body, forming the sheath that envelops the artery which we are obliged to dissect away in order to reach the vessel; it escorts the several blood-vessels to their destination, and accommodates itself to their necessary movements and to their varying volume.

But it is with the young or embryonic connective substance that we are most concerned at present, for, as it served as the mother tissue, so to speak, from which all our organs are evolved in the growth and development of the embryo, so, in the process of repair of wounds and injuries, it is that which grows into the bond of union between parts which have been forcibly separated.

It is thus evident that *the methods by which wounds are repaired are more or less identical in their mechanism with the process of embryonic evolution.* This is what renders a knowledge of these histological facts necessary to us in studying the principles of surgery.

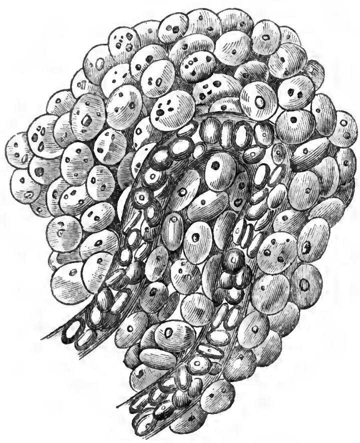
Having thus learned something of plastic lymph and its capacity for organization, of the mode in which its organization is accomplished, and the additional fact that when organized it becomes identical with young connective tissue, it may possibly reward your patience to know that the mass of living tissue represented in the drawing is identical also with what is called *granulation tissue*—i. e., with the material of which the granulating surface of a healing wound or ulcer is composed. If a portion of the soft, velvety surface of a healthy open wound in process of healing be scraped off and placed under a microscope, you will see the same cells and capillary loops; and these granulation cells are likewise tending to development into cicatricial tissue. The little conical eminences with which such a surface is studded, known in surgical language as granulations, each contain a capillary loop, as represented in Fig. 5, which I have taken from Sir James Paget. The red-blood corpuscles are represented as coursing through the vessel, and it is imbedded in a mass of leucocytes, or embryonic cells.

Having recognized the identity of organized plastic lymph with embryonic or young connective tissue, and also with granulation tissue, let us observe the differences which mark the further development of this neo-

plasm into mature connective or cicatricial tissue—according as this development takes place in a "sealed" or in an "open" wound.

In union by the first intention, where the surfaces of a clean cut have been brought together accurately, without contact of air, the development into embryonic tissue of the plastic lymph that so promptly invests these surfaces takes place very rapidly. Vascular connections are promptly established between intervening layers of new tissue and the surfaces of the wound on either side, so that an organized bond of union is at once completed. Under favorable circumstances, in a small wound with smooth surfaces, the whole process requires but a few hours.

Fig. 5.



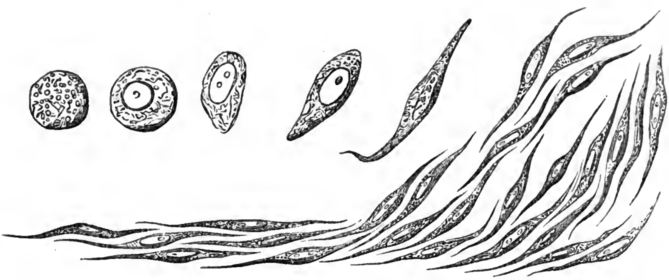
A vascular loop among granulation cells.

Thus, a tumor or outgrowth may follow an injury—a bruise, for example—the effort at repair by the steps I have described extending beyond or beside its normal limits. In such a case the morbid growth will be found to consist of the normal elements of connective tissue ; but, under perverting influences, these may have ceased to *develop* at any stage of the process ; and now, although ceasing to *develop*, they may have continued to proliferate at the stage of growth which they had attained, and the resulting tumor would be found to consist of connective-tissue cells of a corresponding character.

It is of interest to us, therefore, in connection with

the pathology of tumors, to acquire a familiarity with the appearance of connective-tissue elements in their several phases of development. The series of cells represented in Fig. 6, from Paget, gives a correct idea of these elements, from the simple leucocyte on the extreme left—an embryonic cell, or connective-tissue corpuscle, which I have already described—to the fully developed, elongated, fusiform cell of mature connective tissue on the extreme right. *Now, I repeat, at each phase*

FIG. 6.



Connective-tissue cells at different stages of development.

here represented, marking the successive steps by which embryonic substance is developed into mature connective tissue, the process of development—which requires a higher vital effort than simple growth—may be arrested, and growth alone may be continued. So that, as a consequence of a traumatism, a tumor might form, and the histological character of this tumor would be represented by any one of the cells in this series; and, in fact, I have seen examples of each.

Virchow, the great pathologist of Berlin, whose classification of tumors, and whose nomenclature especially, is very much in vogue at present, has given a new and more clearly defined meaning to the old term *sarcoma*. This term, which conveys literally the idea of a fleshy mass, is used by Virchow to designate a group of tumors which, as he expresses himself, pos-

sess an analogy "not only with granulations, but also with true flesh of recent formation or in process of development." These are his own words. (Virchow, "Path. des tumeurs," trad. par Aaronsohn, t. ii, p. 183.) You may understand, then, that a sarcoma is a tumor composed of connective-tissue elements.

There is another term, which took its origin with the Germans and which I have already made use of—the term *neoplasm*. This word means, literally, *new formation*, and it is correctly applied to the newly formed mass of leucocytes and capillaries that I have called embryonic or young connective or granulation tissue. But it is not often used except where the effort at repair has not gone on quietly and kindly to the fulfillment of its purpose. Where a mass of newly formed tissue has accumulated in consequence of some obstruction to repair, it is designated as an "inflammatory neoplasm." As such a growth could only take place in the course of connective-tissue development, it is proper to define the term neoplasm in this connection. It is obvious, also, that in some cases there may not be a wide difference between a neoplasm of this sort and a connective-tissue tumor.

Although a morbid outgrowth in the shape of a tumor might possibly be the result of its exceptional arrest or perversion from a normal course, nevertheless the development of cicatricial tissue in a healing wound, as a rule, goes on safely and surely to its final accomplishment. Coincidently with the maturity of the permanent connective-tissue cell, the intercellular substance, by a process known as *fibrillation*, is converted into the well-known white fibrous tissue. The yellow elastic fiber, the other simple anatomical element in connective tissue, makes its appearance, according to Paget, much later.

The mature connective-tissue cell undergoes no further change. *It remains in a dormant state, imbedded among the fibers which its presence has called into*

existence. Its nucleus may always be brought into view in any specimen of ordinary mature connective tissue—such, for example, as you may obtain in the dissecting-room—by the addition of acetic acid. But during life it may be aroused again to action by any *traumatic injury to the part.* Under this stimulus—the stimulus of injury, as it has been called—the dormant connective-tissue nucleus awakes with renewed germinative force, and may soon become the progenitor of a new swarm of leucocytes.

Notice, if you please, that the only stimulus by which the latent reparative force resident in the dormant connective-tissue corpuscle can be called into action is the stimulus of injury; that connective tissue is universally present in the organism; and that, consequently, upon whatever part of the body an injury may be inflicted, a conservative force is at hand which is inevitably aroused into activity, and by this newly awakened power the injury is to be repaired. This force is garnered up here in the omnipresent connective substance, and apparently in no other vascular tissue of the organism.

Remember, finally, as I have just reminded you, that this dormant force may be called into action, under exceptional circumstances, for an evil as well as for a good purpose.

Thus the knowledge required for the proper understanding of the healing of wounds also sheds a light upon the obscure subject of the ætiology of tumors, and will be of use hereafter in that connection.

But to return to the study of the so-called embryonic, or, as Huxley styles it by way of a synonym, "indifferent," tissue; this term seems appropriate, because in the embryo all the other tissues are evolved from it. For the same reason its cells are sometimes spoken of as "indifferent cells." And I may remark in passing that surgery furnishes not a few illustrations of the fitness of Huxley's designation; for in fracture, where the em-

bryonic tissue is developed between the fragments of a broken bone, at the proper stage of repair its blood-vessels bring a supply of the earthy salts of bone, with which it becomes infiltrated and thus converted into callus, by which the fragments are ultimately united. Again these cells, as far as I can learn, develop into epidermis as readily, at the proper moment, as into connective substance.

I have told you that this substance, call it by what name we may, is identical with granulation tissue, and I have fortified the statement by the indorsement of Billroth and Paget.

In Paget's representation of a solitary granulation you saw blood globules circulating within the capillary loop, and cells of granulation tissue surrounding it on the outside. The walls of this capillary vessel, as I intimated when describing its spontaneous formation, consist of flattened "indifferent cells" which have become united together at the edges, and they also are composed, therefore, of protoplasm. This is true, indeed, of all capillaries.

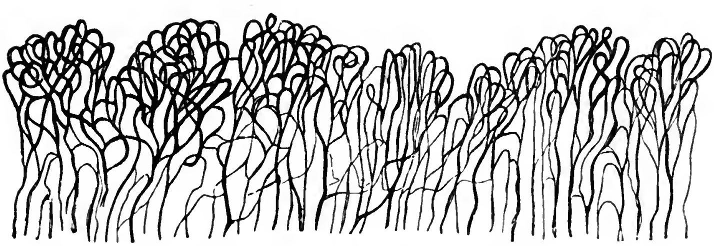
Through these capillary walls, consisting of flattened masses of protoplasm, a constant transudation is taking place of liquid nutritive material derived from the liquor sanguinis. This *liquid exudation*, which is destined primarily for the surrounding cells, is abundantly free and constant during their healthy growth, and it is an important feature in connection with granulation tissue, for, as we shall shortly see, *it is the source of the discharge of pus.*

Now it concerns us as surgeons, in view of the fact that in all open wounds we rely upon granulation tissue to fill up their cavities and ultimately to obliterate them, to know what influences favor the healthy growth and development of this tissue; and for this purpose we must cultivate a familiarity with its appearance and habits, judging chiefly, of course, from the aspect and quality of the granulating surface.

A healthy granulating surface has a soft, velvety look, glistening, somewhat translucent, of a bright, reddish-pink color. To the touch it gives an unctuous sensation, and the idea of a soft, gelatinous consistence. As there are no nerves yet developed in the new tissue, the light contact of finger or probe, or even of caustic, causes no pain. The exceptional sensibility of granulations encountered in some cases is due to a morbid condition of the nerves of the underlying tissue. Rough contact with a granulating surface promptly causes an oozing of blood; and this is sometimes free, for granulation tissue is very vascular.

The cause of the little eminences which form the individual granulations, which the French call *bourgeons*—i. e., buds (of flesh)—is not very clear. It is supposed to be a typical necessity on the part of the new formation to imitate the normal papillary eminences of the skin. It is asserted by Cornil and Ranvier that almost all growths from a tegumentary surface—tumors of the skin and warts, for example, especially those developed at or near the outlets of the mucous canals—affect this papillary structure. A fine injection of granulation tissue with size and vermilion

Fig. 7.



Granulation vessels. Magnified 40 diameters.

demonstrates a corresponding arrangement in loops or tufts at its surface. Fig. 7, from Billroth, gives a magnified view of the injected vessels of an open wound

in profile, showing similar vascular loops, each one of which corresponds to a granulation.

Healthy granulations should be small, conical, moderately firm in consistence, of a bright red-color at their summits, with the depressions between them occupied by a creamy, yellowish-white fluid; this fluid is pus. These are the features of a healthy granulating surface. It would be well for you, whenever opportunity offers, to examine healing wounds and ulcers, using a pocket lens for the purpose, and verify this description.

Individual granulations vary in size and shape, even upon the same healthy surface. They are sometimes larger at the apex than at the base, and not rarely cleft at their summits like a cauliflower.

When cicatrization is ready to take place and is prevented in any way, granulations tend to increase in size and to become overgrown—as around an issue, a seton, or a drainage-tube, or in a wound involving the sheath of a tendon. Under these circumstances a number of granulations may coalesce and form a pouting mass, known popularly as "proud-flesh." *These redundant granulations are always more pallid and flabby than those of healthy type, and their presence always indicates that some cause is obstructing the beginning of cicatrization.* When this cause of obstruction is removed, a slight application of lunar caustic or a dressing with dry lint will speedily repress them.

If there is a lack of vital force, as after much loss of blood from an injury or an operation, the surface of the wound may not show a healthy color, and the granulations often become pale and lose their firmness. Here an improved diet, with wine or malt liquor, and iron, perhaps, internally, are indicated; and slightly stimulating astringent lotions of zinc, dilute nitric acid, lime-water, or tannin in the form of aromatic wine, are suitable applications to the wound. These lotions are most conveniently applied by steeping sheet

lint, or soft old linen or cotton cloth, or prepared cotton wool, in the liquid, applying it to the granulating surface, and placing over this an impermeable tissue of oiled silk or gutta percha, by which evaporation is prevented —in other words, medicated water dressing. This protective, to act perfectly, should extend on all sides a little beyond the saturated cloths beneath, so as to prevent drying and keep the granulations always in a moist atmosphere, and the dressing should be renewed at least every six hours, or more frequently if the suppuration is profuse.

When ointments are more grateful to the patient's feelings, or more convenient for use, the benzoated zinc ointment, vaseline rubbed up with balsam of Peru (ʒj or ʒij of the latter to ℥j of the former), and the common basilicon ointment—the ung. resina of the U. S. Pharmacopœia—are gently stimulating dressings. When the granulations on a wound are pale and flabby, poultices are contra-indicated; they should be replaced by dry dressings of prepared oakum or lint, or some of the astringent or stimulating lotions or ointments named.

Under the influence of mechanical violence, as from rough handling, careless dressing, or chemically irritating applications, granulations are liable to become "*inflamed*"; that is, they grow too red, of a darker tint, become irregular in shape, and, in patches, disappear entirely, being replaced by a sloughy material, or leaving a smooth, dark-red surface, and the wound or ulcer is more or less acutely painful. In this condition a warm emollient poultice, possibly with the addition of some laudanum, and *absolute rest* to the part, will meet the indication—which is to give the resources of nature a fair chance and entire freedom from interference. I must not omit to note that, as a rule, heat and moisture especially favor the growth of granulations. Heat alone solicits a flow of blood to a part, and granulations are known to flourish in a prolonged bath of warm water.

The combination of the two in the form of a warm poultice is a remedy the value of which is indorsed everywhere by popular experience. And yet its good effects are only temporary, and it is always liable to be continued too long; for granulations, like epidermis, may become water-soaked. The anodyne and soothing property of warmth, the soft consistence of a poultice by which it is readily adapted to an uneven surface, and the facility with which it may be medicated, are also valuable qualities in an application for a healing wound.

Other morbid conditions are likely to manifest themselves in granulations when there is a lack of quality in the patient's blood, as from syphilis or scurvy. It is difficult to describe these conditions without clinical illustrations; they lack the appearance of health, and do not flourish; in scurvy, a tendency to bleed is a prominent feature. Their treatment consists in constitutional remedies for these blood diseases rather than any particular local applications. The mercurial lotions—i. e., the black and yellow washes, so called—are likely to agree with granulating surfaces when syphilis is present; and local astringents, like subsulphate of iron, are indicated in scorbutic subjects.

Where a local animal poison or virus has been brought to bear upon a wound or ulcer, as, for example, that of hospital gangrene, or of the contagious venereal ulcer known as chancroid, then the whole process of healing by granulation is blighted. The granulations themselves melt away or die, and their substratum of tissue is converted into what is called a slough, which is a layer of absolutely dead tissue—a moist eschar. I have closely watched the effect of these peculiar poisons, the action of each of which resembles the other in many respects quite remarkably; and I have repeatedly witnessed this result. The presence of the poison is in deadly antagonism with the vital effort, and there is no specific antidote to it in either case. When the virus is destroyed utterly and

entirely (which is possible, for it is entirely local in both of these instances), as by the action of strong nitric acid applied freely to the sloughy surface of a stump in one case, or to an ulcer of the penis in the other, then, after the eschar produced by the caustic has fallen, the normal process of repair is promptly resumed and goes on satisfactorily. But, if any of the poison has escaped destruction, its noxious influence will again manifest itself by progressively blighting the effort at repair, and the remedy must be re-applied.

The condition known as *phagedæna*, which sometimes attacks granulating surfaces, resembles hospital gangrene. The essence of this affection is a progressive molecular disintegration of the surface tissues, which not only sweeps away granulations, but subsequently destroys in the same way the underlying strata. That this disease is also dependent upon a poisoned condition of the tissues attacked by it is rendered probable by the fact that it is more controllable by the same thorough cauterization than by any other remedy.

When a blood poison develops itself in the organism during the healing of an open wound (the subtile and fatal poison of pyæmia, for example) coincidently with the initial rigor that marks the invasion of the disease, the healthy purulent discharge ceases, as a rule, and the granulating surface shrivels and becomes dry. I have more than once recognized this unpropitious change in the previously healthy wound of a hospital patient at my morning visit, and received at the same moment the report of the house surgeon: "This patient has had a chill with a temperature of 104° and a pulse of 125." In the comparatively few cases in which pyæmia does not end in death the blood is sooner or later renewed, and the reparative process in the wound is resumed.

Simple erysipelas constitutes an exception to this statement. I have not infrequently seen a local wound

go on uninterruptedly to cicatrization during the progress of this peculiar disease.

When death takes place suddenly, from some other fatal cause, during the healing of an open wound, its granulating surface will be found, on post-mortem inspection, to have mainly disappeared. It is replaced by the glazed surfaces of the original wound. When the heart ceases to beat, and their blood supply is cut off, the granulation cells shrivel and dry up, or melt away by *liquefaction*—which latter is the most usual mode of death of the leucocyte, and, in fact, of all organic cells.

CHAPTER VII.

Pus: its character, source, varieties, uselessness.

I HAVE thus brought before you some of the influences which favor granulation tissue in its progress toward cicatrization, and some which hurt it and interfere with its purpose; but I have said little or nothing concerning the formation and discharge of pus, which constitutes so prominent a feature in the healing of open wounds.

A flow of pus goes on uninterruptedly from all parts of the surface of every open wound during healthy healing as a part of the normal process. An open wound is necessarily a suppurating wound. The first appearance of pus marks the successful organization of the plastic lymph, the first stage in healing, and coincides with a certain amount of heat and tension of the wound, and often with a febrile movement affecting the whole organism. As soon as suppuration is established in the wound its heat and tension are sensibly relieved, and the increased temperature of the body and the frequency of the pulse, if present, generally subside.

After an amputation, where the wound has remained open and its progress has been favorable, the soft connective and muscular tissues are covered with granulations in from three days to a week; but the harder, white fibrous aponeuroses and the tendons require more than double this time, and the bone remains bare and white for three weeks, or longer. But, unless there is a dead portion to be first cast off, even

10

these unpromising-looking parts in time become invested with a rosy film, and now the whole surface of the wound presents a uniform expanse of granulations. If the granulations are healthy, this is the propitious moment for attempting union "by secondary adhesion." In this event, what would become of the discharge of pus? To answer this question we must first study somewhat more closely the intimate nature of pus, and learn something concerning its source and its significance.

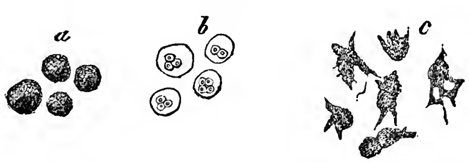
In its most usual form, healthy pus is a cream-like fluid of a yellowish-white color, tending often to assume a pale, greenish tint; it has a mawkish, faintly animal odor, a slightly saltish and rather sweet taste, an unctuous, soapy feel, no viscosity nor stringiness, and an alkaline reaction. Pus is constantly presenting variations from these normal characteristics, according to the circumstances under which it is generated, the tissues at the expense of which it is produced, and its freshness or age. Pus manifests little disposition to putrefaction, even at the temperature of the body, as long as the external air has no access to it; and, when removed from the body and exposed at an ordinary temperature, it is rather slow to undergo change.

When allowed to stand quietly for some hours, pus gradually separates into two portions: one *solid*, which, under the influence of gravity, sinks to the bottom of the vessel; and another, *liquid*, and lighter in color, which floats. The solid portion of fresh pus consists almost entirely of leucocytes, which are here called pus corpuscles; its liquid portion is a serous fluid called *liquor puris*. They bear a relation to each other like that which exists between the corpuscles of the blood and its *liquor sanguinis*. In normal pus of average quality, its solid portion (corpuscles) constitutes about twenty-five per cent of the whole, three quarters of its bulk being, therefore, *liquor puris*. But this proportion may vary greatly, in most cases

by diminution in quantity of the corpuscles. Thus, in the thin, serous, watery pus that comes from an open wound on the eve of healing, or in that furnished by an indolent ulcer, the proportion of corpuscles may sink as low as two or three per cent, while in the thick, creamy discharge from a healthy granulating wound it may rise as high as twenty-nine per cent (Robin). The presence of *thick* pus, as a general rule, indicates active progress of the reparative process; it shows that cell proliferation is going on luxuriantly; it is the "laudable" pus of old authors. *Thin* pus means just the contrary—either that the healing process has reached a natural termination, a cicatrix being about to close in the suppurating surface, or that it is otherwise interfered with or suspended. You can understand now what our surgical fathers meant when they spoke of the discharge from a wound as "*bonum et laudabile*," i. e., good and praiseworthy; "laudable" pus being rich in newly formed organisms, good in quality, and promising as to rapid healing.

When we investigate the anatomical characteristics

Fig. 8.



Pus-cells from fresh pus, magnified 400 times. *a*, dead cells; *b*, the same cells after addition of acetic acid; *c*, various forms that living pus-cells assume in their amœboid movements.

of pus after separating its *solid* portion from the *serum*, we find that more than nine tenths of the former consists of leucocytes, or pus-cells. These latter, viewed under the microscope in freshly formed pus, present individually the granular aspect, and also the amœboid movements of vigorous, young, healthy leucocytes, as delineated in Fig. 8.

In pus which has been collecting in an abscess for several days, or which has been discharged from the body for a few hours, these movements indicating life are no longer to be seen. The pus corpuscles, under these circumstances, present themselves as cells, with from two to five nuclei—most generally three—and these are in a cluster resembling a clover-leaf. This is generally considered and pictured as the most characteristic form of the pus corpuscle. But whenever the pus corpuscle presents this aspect it is dead; it is no longer capable of amœboid movements. A film, constituting a sort of cell-wall, seems to have formed around its outer surface; it is uniformly round. When subjected to the action of dilute acetic acid it dissolves—all except the outer film or cell-wall, and the central trefoil-shaped nucleiform mass.

These two varieties of pus-cells, living and dead, are often seen mingled together in various proportions in an ordinary specimen of pus.

In pus which has been formed for some days, and confined in contact with the tissues, there are also found larger corpuscles, overgrown, as it were, and stuffed with granules of fatty matter in addition to their nuclei; these are simply obese pus-cells which have fallen into fatty degeneration. Minute drops of free oily substance also, as well as granular *débris*, are almost always present in pus, derived from the breaking down of the overgrown granular corpuscles just mentioned, or from neighboring adipose tissue. More rarely the delicate needle-shaped crystals of the fatty acids—the margaric and stearic—may be detected. It is the presence of this small amount of fatty matter in pus that gives it the odor, when boiled, of boiled milk. A certain portion of this fatty matter enters into combination also with the salts of potash and soda, which are always present in the serum of pus; and this explains its soapy feel. Cholesterine, recognizable by its broad, rhomboidal, crystalline plates, is also sometimes seen

in pus, especially in that from the testes, the broad ligaments, and ovaries, and in pelvic and psoas abscess.

Among the accidental elements sometimes seen in pus are the minute infusorial organisms known as *vibriones* and *bacteria*. *These living microscopic bodies have just this signification, and apparently no other, namely, that the pus in which they are found is about entering into decomposition, that its vital quality is at a low ebb, and that chemical forces are in the ascendant.*

While examining pus under the microscope we constantly meet with blood-globules mingled with those of pus; they come from the rupture of capillary vessels from over-distention. The admixture of both blood and oily matter with pus is often apparent to the naked eye in larger proportion, as when the contents of an abscess have been evacuated by incision through vascular and fatty tissues. Minute granules of bone-earth are sometimes found in pus which has formed in contact with diseased bone. *Under all circumstances, the débris of the tissue at the expense of which pus is formed is liable to be present in it in larger or smaller masses.* Pus, as we shall see hereafter, is never formed unless the tissue in which it forms has undergone injury to some extent, however limited; and the germs from which the leucocytes take their origin in the resulting plastic lymph are also derived from the injured tissue, i. e., from its connective-tissue stroma and from wandering white corpuscles.

The serous portion of pus, when separated from its solid materials by careful filtration, presents itself as a clear, slightly alkaline, albuminous liquid containing no solid particles whatever. It constitutes, in an average specimen, at least three quarters of the weight of the pus; and, although derived directly from the blood, through the walls of the capillaries, in the form of liquid exudation, it nevertheless differs from the plasma of the

blood, as well as from the ordinary serum of dropsies. (Robin.)

Liquor puris owes its alkaline reaction to the presence of salts of soda with excess of base; it also contains chloride of sodium and the phosphates of soda, lime, and magnesia—more of the two latter when the pus has formed in contact with bone. The addition of nitric acid will always cause precipitation of its albumen. In decomposition, or whenever ammonia is present, the well-known large prisms of the triple phosphate of ammonia and magnesia can be detected in pus. They are generally present in the dried pus that collects around a wound.

In the exceptional cases in which pus reddens litmus-paper there is rancidity in consequence of the generation of butyric and other fatty acids.

When liquor potassæ or aqua ammoniæ is added, in a very moderate quantity, to pus in a test-tube, and the two substances shaken together, a curious semi-solid, translucent mass results which has the consistence of dense mucus. The pus-cells are dissolved by the alkali, which also reacts upon the albuminous compounds in the liquor puris. The slimy substance which forms when the parts around an open wound are washed with soap and water is a result of this peculiar reaction of pus with the alkali of the soap. It explains also the characteristic ropy mucoid discharge from the bladder in cystitis whenever ammonia is set free in the urine. This is liable to occur, by decomposition of urea, whenever there is habitual delay or difficulty in entirely emptying the bladder.

We have next to consider the *source* of pus. The first question that presents itself is this: What is the force that brings leucocytes to the surface of a granulating wound, to be discharged thence in the form of pus? This force is found in the *liquid exudation*, the supply of which, in a suppurating surface, from the capillaries both newly formed and old, is copious and continuous

until arrested by the ultimate cicatrization of the wound.

This constant supply of nutritive material for the growing cells, in a wound healing by the second intention, is in excess of the demand. After percolating through the mass of granulation tissue, the excess of liquid reaches the granulating surface, carrying out with it a certain proportion of the leucocytes among which it has passed, and makes its appearance there as pus.

A simple experiment will serve to show that this is not theory, but demonstrable fact. Carefully dry off the surface of a granulating wound by means of some soft absorbent, such as prepared cotton, and then apply an irritant; for instance, sprinkle common salt upon it, or bring a red-hot iron almost in contact with it, and you will see myriads of minute drops exude, like sweat, from the surface thus momentarily dried; place a drop of this fluid under the microscope, and you will find leucocytes in numbers; in fact, it is pus (Cornil and Ranvier, *op. cit.*, p. 99).

Under all the various circumstances in which pus is formed in the body, and in all localities—whether on the surface of mucous or serous membranes, or in the depths of the tissues—these, as in a granulating wound, are the factors which contribute to its formation: *liquid exudation from capillary vessels, and leucocytes.*

A surface of granulation tissue is therefore by no means the only source of pus. As we shall shortly see, it may form, under certain conditions, in any part of the body. I mean by this statement that no previously formed granulating surface, or so-called "pyogenic membrane," is necessary for the formation of pus. *The first phenomenon that attends its production is liquid exudation; the next, cell proliferation.* You may understand now why Robin designates pus "an accidental secretion," and why Billroth insists upon calling it "liquid neoplasm."

On the other hand, it is to be distinctly kept in mind that granulation tissue may form, grow, and develop into connective or cicatricial tissue—as between the ends of a subcutaneously divided tendon—without the formation of a drop of pus.

I have now brought before you some evidence as to the nature and sources of pus; but we have not yet considered its *uses*. For what purpose is pus secreted from our blood at the expense of our tissues?

Formerly the flow of pus was supposed to exert a depurative influence both upon the wound and upon the system at large. It was thought to cleanse a wound and prepare it for healing; and means were commonly employed to promote its flow. The popular mind still attaches importance to the idea that suppuration purges the body of something injurious; and the term "corruption" is still applied to pus, and a certain satisfaction excited by its free discharge. Hence, also, one source of confidence in setons and issues as remedies.

But, at the present day, the conviction has gradually come to prevail that these uses of pus are imaginary. They certainly are not confirmed by the growing accuracy of our knowledge, and the opinion of Robin remains undisputed. He says: "*It can not be demonstrated that, under any circumstances, suppuration does good, or that it exerts any salutary influence by depuration*" ("Des Humeurs," p. 384).

We are to regard suppuration, therefore, simply as an exuberant overflow of plastic material. The leucocytes that are washed away by the flow of liquid exudation are evidently not absolutely necessary for the constructive process. They are in excess of the demand. Their fellows, which remain behind, develop into tissue: they subserve a useful purpose; but the pus corpuscles are wasted: *they are abortions.*

I think you will recognize that the truth of this view is demonstrated by what happens when healthy granulating surfaces are brought in contact with each

other and kept gently and firmly in apposition. We know by experience that they unite and grow together at once. I have asked the question, What, in this event, becomes of the pus? The answer is, It ceases to be produced the moment the granulating surfaces are successfully brought together. *The immediate call for organization and development, in the new attitude of the wound, affords ample scope for both the force and material hitherto wasted, and its overflow as pus is at an end.*

I will give you evidence, on another occasion, that suppuration is not only useless and wasteful, but that it is otherwise positively injurious.

Meanwhile it is to be observed that, when it can not be cut short by getting union by adhesion of granulations — a possibility which the intelligent surgeon should always keep keenly in view—the normal termination of suppuration comes through the *repressive* influence of cicatrization; and this, the process of cicatrization in open wounds, will next claim our attention.

After a longer or shorter time the cavity of every open wound becomes filled up by the constantly growing granulation tissue. The granulations even sprout, in the redundancy of their vigor, beyond the edges of the wound, and require means to be used for their repression. As a rule, when the granulating surface has reached the level of the edges of a healthy wound, or usually even a somewhat higher level, a sensible contraction in its area begins to be noticeable; the raw surface shrinks, as it were, and, simultaneously, the process of *cicatrization* begins. The borders of the healing wound begin obviously to pucker in; from having been more or less *everted*, they become decidedly *inverted;* they shape themselves so as to become smoother and more beveled, and to terminate, toward the granulating surface, in a narrow, shelving border of a more decided red color; and this again merges

into a still thiner edge of a bluish-white tint. This latter, a delicate, pearl-colored pellicle, although slightly below the level of the granulations, *is evidently encroaching upon their surface;* and it continues to advance uniformly upon all sides, from circumference toward center, *like a lake freezing from its banks.* Thus in time the whole granulating surface of the wound becomes covered in—*repressed*, as it were, as to further growth—by the smooth, glossy, pinkish-colored film of cicatricial tissue. I would advise you to seek opportunities to watch this process with a pocket-lens. The extent of a cicatrix, in consequence of the insensible but very decided shrinking of the mass of granulation tissue which has taken place, and which sometimes puckers in the surrounding soft parts in a remarkable manner, is always very much smaller than the original size of the wound.

A cicatrix consists, on its surface, of the film of epidermic cells which has thus covered in the wound; and it continues to be re-enforced from beneath by the rapidly advancing development of the granulations into connective tissue—the simultaneous arrest of waste of material in the shape of pus corpuscles conducing to this end.

The indifference with which the leucocytes of a wound's surface develop, not only into the epidermic film just described, but also into true skin beneath it, and into superficial fascia beneath true skin, would entirely justify Mr. Huxley's designation of them as "indifferent cells," if it were certainly and absolutely true. It has been said that the stimulus to the first effort at cicatrization *is derived from the simple contact of the epidermis at the edges of the wound with the granulations when they have reached its level*, and that it is from the contact of the epidermic cells that the repressive impulse restricting further growth is received and the cicatrizing process is begun.

The discovery made by M. Reverdin, of Geneva,

gives plausibility to this assertion. He has recently taught us that small clippings, or grafts from living skin, if applied upon a granulating surface at its center or at any point in its area, will excite the formation of new epidermis around them, the process being attended by the same phenomena of commencing cicatrization which I have just described.

A cicatricial film does not possess the power of advancing beyond a limited distance from the edges of a granulating surface, and, until they are covered in by the epidermis, the leucocytes beneath do not begin to develop into true skin. The distance from the edge of a wound to which the cicatricial film is capable of extending is less than is generally supposed, for it is always aided by the contraction of the developing connective tissue, and often by the adhesive plaster of the surgeon, applied so as to approximate the wound's edges. In fact, too much credit is usually accorded to the power of cicatrization. Practical surgeons are well aware that wounds and ulcers presenting a large area can not be relied upon to cicatrize beyond a certain limited degree. I once amputated a limb, before the introduction of skin-grafting, for an extensive ulcer following a burn which had resisted all means employed to heal it. There was also deformity in this case from contraction of the elbow-joint. Here the early employment of skin-grafts might have prevented both the contraction and the incurable ulceration, and so saved the limb.

The impulse to cicatrization, caused in their immediate vicinity by skin-grafts, extends to a distance not exceeding one third of an inch in every direction from the graft as a center; and it then ceases. A constant succession of fresh grafts is therefore required when the surface to be cicatrized is extensive.

In a young woman whose whole scalp had been torn off by machinery, and who was recently treated in one of our hospitals, the patient survived the mutilation,

but there was great difficulty in getting cicatrization. I learn that more than ten thousand grafts were applied in this case from 1875 to 1879. Reverdin's discovery has proved to be of great practical use, for a remedy capable of starting or of expediting the process of cicatrization has always been a desideratum.

Before the introduction of this novel and valuable resource, treatment of a large ulcer refusing to cicatrize on general principles was almost hopless. Approximation of the borders of the ulcer by the method known as Boynton's, and rest, were used; a sea voyage was regarded as the most promising means of cure for delayed healing when all other means failed. I have frequently proved the beneficial effects of this measure, especially after extensive operations for fistula in ano and in old ulcers. The explanation of the great advantage that so often follows this remedy lies in the thorough change in the patient's habits and surroundings, and the improvement in the quality of the blood from breathing purer air.

The great importance, in promoting the healing process, of an improved quality of the blood, which is so liable to be loaded with impurities, is illustrated by the almost magical effect that follows the administration of the iodide of potassium, in a sufficient dose, in the tertiary ulcerations of syphilis. There is no fact in therapeutics more constant and more striking than this.

Not only the quality of the blood must be good, but, in order to secure prompt cicatrization of wounds and ulcers, the supply of good blood to the part must be sufficient and constant. We see proof of this in the rapid improvement in chronic varicose ulcers of the leg, where the blood supply is defective in consequence of venous stagnation, under the use of the caoutchouc bandage introduced by Dr. Martin, of Boston. Any well-applied bandage or accurately fitting elastic stocking will serve to equalize the local circulation under these circumstances, but none, in my observation, so certainly

as this bandage, for the patient can be taught to apply it himself; and the prompt good effects that follow secure in most instances its faithful use until a cure is effected. The stagnation of blood in the enormously distended superficial veins of the leg when varicose prevents effectual drainage of the parts around the ulcer, and keeps them always congested, with a stagnant capillary circulation. Under these circumstances the granulations are imperfectly formed and livid in color, and there is little or no progressive repair. The bandage, by equally compressing the enlarged surface veins, replaces their useless valves; the blood is forced into other actively working channels, the congestion is relieved, and normal circulation restored. A healthy color now returns to the ulcer, its granulations become regular in shape and active in growth, and in a little time its cicatrization is accomplished—often with nothing but a simple water dressing in immediate contact with the ulcer.

Now that we have reached its natural termination by cicatrization, it will be profitable to examine in rapid review the more important features of the healing process.

The great advantages of quick healing (only to be secured where access of air is cut off) over healing by way of granulation and suppuration, as in open wounds, are, I trust, sufficiently obvious. There are no reasons at the present day which justify the surgeon in giving preference to the slower method and exposing his patient to its greater dangers. When a wound can be so dressed as to certainly prevent access of air and to secure perfect rest, there is, as a rule, little or no pain, heat, redness, and swelling—symptoms of that condition so much dreaded popularly under the name of inflammation. When the wound is open, these symptoms are more prominent and more liable to occur. They may subside early, as I have described, when the process goes on favorably; but favorable progress is

liable to interruption in many ways, as we shall see hereafter; and the longer a wound remains open the greater the danger to which the patient is exposed.

Paget speaks of the "period of mysterious repose" after the infliction of a wound before the appearance of granulations upon its surface—a period measured by days for the softer and more vascular tissues, and by weeks for the harder tissues with fewer blood-vessels. But this appearance of repose is confined entirely to the wound's surface as viewed by the naked eye. Beneath its surface there is a tumultuous activity in the way of cell germination. In proof of this, witness the

FIG. 9.

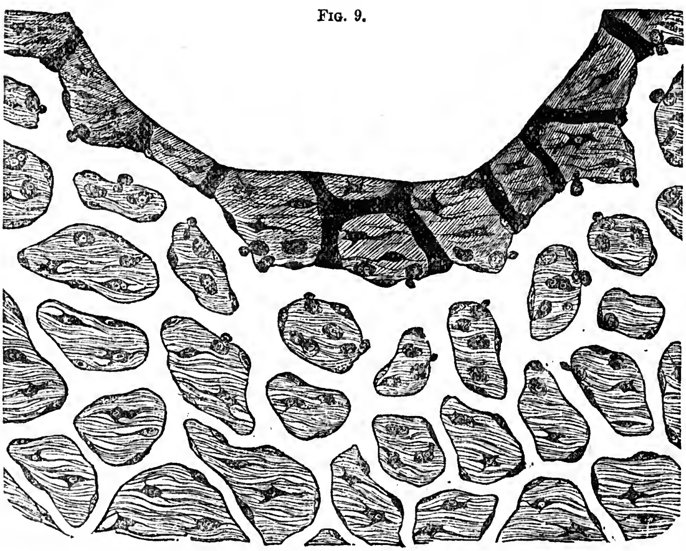


Diagram of a wound, with loss of substance. Vascular dilatation, magnified 300–400 times.

important changes which have been accomplished in the tissues just beneath the surface of the wound, as well as upon it, during the interval before the appearance of granulations. These are represented in Figs. 9 and 10 from Billroth. Fig. 9 is intended to show the

capillary network of connective tissue after a surface wound attended by loss of substance. The flow of blood here has been stopped by coagulation immediately after the wound in the divided capillaries, the coagula extending to the nearest collateral branches. Beyond, the capillary vessels show marked dilatation, resulting from the increased pressure upon them, in consequence of the obstructed branches, and the increased fluxion of blood, which always takes place toward an injured part. This distention is about to be relieved by liquid exudation through the walls of the distended capillaries; and the exudation, traversing the meshes of the connective tissue, appears upon the surface of the wound, and coagulates there as plastic lymph. As there is here no opposed surface similarly situated to which it could be applied, as when surfaces are brought together for primary union, the layer of plastic lymph gradually becomes organized into richly vascular granulation tissue, which continues to grow from its surface and to discharge its exuberant elements in the form of pus. Fig. 10 represents the changes which have taken place in and beneath the same surface wound on the third or fourth day, when suppuration has been established. Its principal features are, first, the greatly increased numbers of young cells extending to the surface, where they form the layer of granulation tissue which covers the wound, with its surface covered with pus-cells; and, second, the newly formed capillary loops bringing the blood supply. The former *dilatation* of the capillary network no longer exists, since the blood finds vent through the newly formed channels. This latter change corresponds with the external visible tension, or swelling, around the wound, which I have already described as disappearing coincidently with the appearance of pus. And this coincidence—namely, the subsidence of swelling and the occurrence of suppuration—has, no doubt, had its effect in begetting the popular

impression in favor of the good influence of a free flow of pus.

Now, all this means that Nature, during this period of apparent but not real repose, has been quietly or-

Fig. 10.

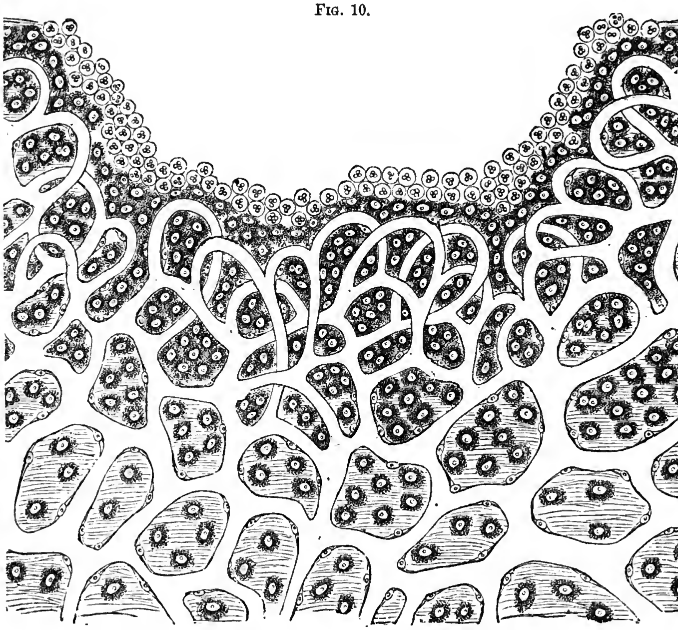


Diagram of granulation of a wound; the layer of pus-cells is represented as having been acted on by acetic acid, to distinguish the pus-cells in the figure more accurately from the granulation cells. Magnified 300–400 diameters.

ganizing her forces, and that she is ready to produce a growth of young connective tissue wherewith she proposes to heal the wound.

Although, while studying side by side the phenomena that attend the healing process and the resources at our command by which we can assist it, we have arrived at its ultimate stage—that of cicatrization—there are yet some remaining points of interest in relation to granulations, and still more concerning pus, which ought to be considered in this connection.

You have seen that granulations are richly supplied with blood-vessels. Now, the proportion of blood-vessels in a given mass of granulations bears a direct ratio to its power of healthy and rapid growth and development. Only blood of a good quality can furnish material for the luxuriant growth and development of cells and capillaries. Even in old granulating surfaces where healing has been long prevented, as where a piece of dead bone remains to be got rid of before an ulcer or sinus can heal, the granulations are still without sensibility—showing that no nerves have developed in them—but the slightest touch will make them bleed, for there is no lack of vessels yielding meanwhile a lazy exudation and discharge of thin pus. They may remain in this waiting attitude for years; but, as soon as the dead bone has been removed, their growth will be at once resumed, and they will develop forthwith into firm cicatrix.

The vascularity of granulations accounts also for their *power of absorbing* into the general circulation soluble substances in contact with them. The absorbent power of the capillaries of granulations is in no degree less than the well-known power in this respect of capillary vessels elsewhere, as shown, for example, in the rapid effects of a subcutaneous injection of morphine. Hence the necessity of caution in using poisonous drugs as applications to wounds and ulcers in dressings. Hence also the possibility of the absorption of noxious materials generated in a wound, or brought in contact with it by dust in the air, sponges, dressings, or by manual contact. This power of absorption, which resides in every granulating wound, diminishes, of course, in proportion to the advancement of cicatrization.

It is an established fact that patients with open wounds in crowded hospitals are liable to erysipelas and pyæmia, while those without open wounds usually escape. Admitting that the avenue of entrance for the

poisons, which give rise to these diseases, into the blood by means of the foul air respired is both common and direct, nevertheless, the fact of greater danger incurred by patients with open wounds, so well set forth by Erichsen, remains as additional evidence of the power of absorption belonging to granulating surfaces. *Apparently the only difference between the rapidity with which morphine is absorbed into the circulation* when injected beneath the skin, and when the same substance is sprinkled upon a granulating surface, is due to the outward flow of pus constantly going on from the latter, by which a certain proportion of the drug is floated away from contact with its capillary vessels.

Leucocytes undergo change into characteristic pus-cells with clover-leaf shaped nuclei in consequence of impaired nutrition, because of their removal from contact with or the immediate vicinity of the capillary vessels of the granulation tissue, for they are cut off from all chance of further development when they have been floated to the surface of a wound.

The *consistence* of pus under ordinary circumstances depends entirely upon the proportion of its solid constituents, i. e., the proportion of cells present in it; so also does the depth of its color. This proportion varies, as I have already stated, from two or three to nearly thirty per cent. In certain localities pus presents the consistence of a soft solid, as in abscesses developed, under pressure, in the spongy structure of bone; here the serum has been absorbed, and the pus-cells, having undergone fatty infiltration, assume an angular shape in consequence of mutual pressure. Such collections of solid pus *have been not infrequently mistaken for tubercles;* but the pus-cells will always swell out when water is applied to them, and they will also show their clover-leaf shaped nuclei on the addition of acetic acid. Solid pus occurs also, habitually, in other localities: in the depressions between the circumvolutions on the surface of the brain and spinal cord in meningitis; on

the iris, where it can often be seen in the form of little rounded masses in iritis, in the cornea, and in other tissues of the eye.

A peculiar proximate organic compound called pyocyanine has been discovered in pus by M. Fordos, which gives it the greenish tint so often noticeable. When present in unusual quantity, this substance may give pus, in rare instances, a positively blue color (Robin, *op. cit.*, p. 410). This latter tint is also sometimes caused by the growth of a blue fungus upon dressings which have been left long unchanged. This microscopic fungus is, according to Robin, a variety of the protococcus (*id.*, p. 409). Pus from abscess of the liver is liable to be colored of a deep yellow, green, or brown, by the coloring matters of bile. All other shades of orange or red are due to the presence of red corpuscles of the blood in different conditions or quantities, or to their coloring principle, hæmatoidin. These unusual colorations have no practical significance except, perhaps, in diagnosis.

When pus gives off a *fetid odor*, if this is not caused by the admixture of dead and sloughy material foreign to its own substance, it is the result of actual or approaching decomposition. In decomposition, the sulphates of its albumen become sulphurets, and free sulphureted hydrogen is extricated, which combines with the ammonia given off at the same time. There is also a trace of phosphureted hydrogen present, which contributes to the odor. Decomposition of pus often takes place around a wound, where it collects and dries upon the surface in consequence of the high temperature of the body. When lotions containing lead are employed under these circumstances, the dressings are liable, as I have already mentioned, to be colored black by deposit of the sulphuret of lead.

But pus may derive a bad odor from other sources than the sulph-hydrate of ammonia and the other results of its own decomposition. The power by which

gases permeate animal membranes explains the fœtor of abscesses forming near the rectum, or, in fact, in the neighborhood of any part of the alimentary canal. The badly smelling gases generated within the canal are absorbed by the pus formed outside of it, through the intervening membranes. This is true of pus forming in the neighborhood of the mouth, tonsils, pharynx, and œsophagus. A peculiar sour smell has been noticed in pus from the vicinity of the small intestine, suggestive of the earlier stages of digestion. There is, consequently, a certain diagnostic value in the odor of pus. If the discharge from an abscess of the neck should be offensive, it may be safely assumed to come from a source as deep as the pharynx. In pus which is confined, and at the same time mixed with the secretions of an inflamed mucous membrane, as in that which occasionally collects in the antrum of the upper jaw, the fœtor is excessive ; and here also I have seen pus quite solid in consistence. In *ozœna*, or where dead bone is present, or a foreign body is wedged in the nasal cavities, it is notoriously offensive. It is noticeable that in each of these cases the odor is peculiar, and differs from the others.

Substances absorbed into the blood give their odor to pus. A French author states that ulcers of the leg in tanners, who work in badly smelling hides, are remarkable for their extreme fœtor ; and I have certainly recognized the odor of the dissecting-room in the pus of an abscess following a dissecting wound. The pus from buboes of the plague is described as smelling horribly, and that from the pustules of small-pox is notoriously offensive.

The constitution of pus is subject to constant variety, not only in different individuals and forms of disease, and in various localities in the body, but in different conditions of the same individual. Under the influence of an attack of indigestion, for example, the character of the pus from a healthy granulating wound

will give evidence of temporary change ; and after a chill, as of pyæmia, as I have said, it usually becomes scanty, thin, and watery.

This circumstance in part explains the name which is wrongfully borne by the disease usually called pyæmia—i. e., pus in blood—and also explains its synonym, "purulent infection," still employed by some surgical writers. The sudden disappearance of the purulent discharge from a wound, simultaneously with the chill by which grave symptoms are ushered in, naturally suggests that the serious change in the patient's condition is caused by "absorption of pus"; and the abscesses in the internal organs which follow, formerly called metastatic, seem to lend support to this idea. But the doctrine of purulent absorption, which was taught by Velpeau when I was a student in his service forty years ago, is now *known to be unsound.* Unfortunately, the terms *pyæmia*, *purulent infection*, *and purulent absorption,* based upon this unsound pathology, are still in current use. We believe now that the series of grave and too often fatal symptoms which they are employed to designate has its origin in the introduction into the blood of poisonous material derived from other sources, and *that this poisonous material is not pus.*

Normal pus, unless some virus or poison may have been accidentally introduced into it or mingled with it, is a bland, innocuous, unirritating fluid. Its injection experimentally into the veins of animals has been followed, it is true, by internal abscess and death ; but these consequences were due to another mechanism entirely—namely, to coagulation of the blood by the *dead corpuscles* injected ; these acted as foreign material in the blood, and the subsequent arrest of the coagula thus formed, when carried onward in the blood-stream to the smaller vessels, provoked pus formation as foreign bodies. Their arrest occurs most frequently in the capillaries of the lungs, and abscesses form there

as a sort of necessity. This process, now known as thrombosis and embolism, will be again discussed. Now, precisely similar results to these caused by the experimental injection of pus into the veins of animals have followed the introduction of otherwise innocuous powders—such as ivory-black or metallic mercury into the circulating torrent; for minutely divided substances, as we have learned already, have the faculty of causing its prompt coagulation when brought in contact with the blood; and we shall shortly learn that foreign or dead matter lodged in the tissues is a recognized cause of abscess.

Where a wound or an ulcer is partly gangrenous or phagedenic—in fact, up to the time when a complete layer of healthy granulations has formed upon its surface—its pus will always contain more or less dead or dissolving tissue—*detritus*, as it is called. The yellowish, flocculent, or leathery adherent material, which can not be washed away from the bottom of a wound or ulcer in this condition, is simply dead tissue not yet cast off, because granulations are not completely organized beneath it. When a virulent poison is present, as in the pus of a chancroid, this circumstance, as already stated, seems to prevent or delay the formation of granulations, and thus explains the slowness with which these sores heal.

Pus from the surface of a healthy granulating wound is said by Robin to contain, almost always, some epithelial cells, especially if it is approaching cicatrization.

Pus from varicose and other ulcers of old men, from ulcerated epithelial tumors, from the true syphilitic chancre, and also from phagedenic ulcers, is thin, serous, and "sanious," significant of the absence of healthy effort in the way of repair; besides detritus of tissue, it often contains vibriones and bacteria, and tends to putrefy. The type of *sanious* pus, of what is called *ichor*, which, although thin and watery, contains much

already dead or liquefying cancer tissue, is found in the discharge from an open cancer. Remove the cancerous growth freely and entirely, and, if the wound be left open, the surrounding healthy tissues will shortly yield thick, cream-like pus, significant of active cell formation and rapid repair. Cancerous ichor is often excessive in quantity and exhausting to the strength; it is given off by the new vessels of the cancerous growth, which are impotent to furnish true exudation, and simply exhaust strength in the effort.

And now, gentlemen, reasoning from the facts already stated, we are justified in the conclusion that if pus is not poisonous in its nature, as was assumed in the exploded doctrine of purulent absorption, *it is at least useless.*

But there are certain circumstances under which this fluid does acquire poisonous properties which do not belong to it *per se*, as when it becomes accidentally the vehicle of a *virus*—as, for example, of the peculiar virus of the contagious venereal ulcer-chancroid. Under these circumstances it is properly denominated "virulent pus," an expression habitually employed in this sense by Ricord and most writers on syphilis. Here there is no difference whatever, discoverable by the microscope or by the strictest chemical analysis, between virulent pus and pus of ordinary quality.

The *virulence* of pus thus contaminated belongs neither to its corpuscles nor to vibriones or bacteria which it may contain, but to certain unknown substances soluble in its serum, analogous to those which exist in the blood in syphilis, in the nasal mucus of glanders, in the saliva in hydrophobia (Robin, *op. cit.*, p. 414). The probable nature of these intangible viruses will occupy our attention hereafter. I wish especially to disabuse you of any suspicion that vibriones or bacteria hold any relations to these poisons. These microscopic organisms, as Pasteur has shown, bear to putrefactive fermentation just the same relation that the yeast plant

bears to the fermentation that takes place in bread or beer. Vibrio and bacterium are names applied to microscopic vegetable organisms of the family of infusoria, and the fungus or mushroom class. They are endowed with a certain power of motion, and hence were long regarded as animalcules. They are constantly met with in our tissues, secretions, and excretions, healthy and morbid. In struggling for their own existence, these microscopic mushrooms cause chemical decomposition, in which gases are disengaged, of the material in which they are developed, and therefore act the part of what are called ferments, and the process to which they give rise is hence called putrefactive fermentation. These fungi are entirely analogous to the yeast plant in their power of causing fermentation.

We have seen that pus, in its solid forms, has been mistaken for tubercle, but its identity subsequently established by the swelling of its distorted cells and the discovery of their nuclei on the addition of water and acetic acid. Now, on the other hand, there are fluids in the body, and even solids, which are often miscalled pus, in which the microscope fails to reveal its characteristic elements. As examples I will mention the fluid effused in peritonitis or pleurisy, called purulent, but often nothing more than the serum of those cavities with a few leucocytes in suspension. An exaggerated flow of mucus from any of the mucous canals, with an increase in number of the leucocytes which it normally contains, often forms an imitation of pus, as in bronchorrhœa or some forms of gleet, and especially rectal mucus when colored yellow by bile. The fluid found in the pelvis of the kidneys after death resembles pus, but it is only urine holding in suspension epithelium from the urinary tubules. A similar explanation applies to the fluid which can be pressed out of the prostatic ducts. The secretion of the tonsil collected in its crypts is not infrequently mistaken for pus, and ulceration assumed to be present, when it is

not. Clots which form in arteries after ligature, and elsewhere, as after embolism or plugging, are liable to break down into a soft, yellowish fluid strongly resembling pus (Virchow's "Lectures on Pathology," translated by Chance, London, 1860, p. 200); and a similar puriform liquefaction is liable to take place in other tissues—as in lymphatic glands, sometimes in the testicle, and, more rarely, in the interior of fibrous tumors.

The formation of pus on the surface of a serous or mucous membrane, as in pleurisy with effusion or in urethritis, is attended by less of a vital effort than its formation after a wound, or in an abscess, or even in a boil; for leucocytes, it must be remembered, already exist as a part of the secretion of these membranes in a state of health, and the conversion of these secretions into pus involves only increased activity in cell germination on the part of the young epithelium.

I am not aware of any recognizable distinction yet demonstrated between the young round cells of epithelium and ordinary leucocytes. The exudation constantly taking place from the underlying network of capillaries of every serous and mucous membrane furnishes nourishment for the epithelium which is being constantly renewed on the free surfaces of these membranes. Now, if the equilibrium of health be disturbed—say in consequence of prolonged chilling of the body, as in pleurisy, or through the contact of a poison or a virus, as in gonorrhœa—the injury thus offered creates a fluxion of blood to the capillaries of the membrane, and a tendency to increased cell proliferation. The result is increased liquid exudation, carrying off the excess of cell production; in other words, a discharge of pus.

These phenomena are usually, but not always, attended by pain, heat, increased redness, and swelling of the affected membrane. A return to a state of health is marked by diminished fluxion and consequent diminution in cell production. The cells resume their nor-

mal tendency to develop into epithelium; the pus just in the same proportion becomes thin and watery, and finally, as soon as the normal conditions are completely restored, it ceases.

Notice that an injection of dilute ammonia, a purely chemical irritant, would give rise to a similar succession of phenomena. In the experiments of Cornil and Ranvier a solution of nitrate of silver thrown into the peritoneal cavity of a rat was followed by similar exfoliation of epithelium and proliferation of leucocytes. On serous membranes, however, except where the injury is excessive and sustained, increased cell proliferation tends to prompt tissue formation resulting in adhesion, and the formation of what are called false membranes, and *not to pus production.*

The vital effort which results in the formation of pus among the solid tissues of the body (which we shall shortly study under the head of abscess), just as in wounds and on membranous surfaces, inevitably involves a destruction of existing tissue, besides the wasteful overflow of anatomical elements which we have already recognized.

Wherever healing has followed suppuration there is evidence, in the depression of the cicatrix and in the general shrinkage in volume of the parts involved, that there has been loss rather than gain as to bulk—certainly also as to quality—of organized tissue. A cicatricial surface never contains sweat glands nor hair bulbs. "But," it may be asked, "is not the healing of the wound to be credited to the suppuration?" By no means and in no way. A moment's reflection will recall the facts that the most prompt and solid healing, with least loss of substance, is accomplished in primary union, in subcutaneous consolidation of a divided tendon, or in that of a simple fracture, where there is no pus formation whatever; in short, that new tissue is freely generated without its aid.

Again, you will see many examples in the wards of

the hospital of patients wasting with suppuration who are benefited by cod-liver oil; you will see cases of amputation for injuries of limbs which nature's resources have failed to heal, where improvement in the patient's condition has begun at once after the removal of a source of exhausting and impotent suppuration. What is called hectic fever is coincident with, if not caused by, suppuration from surfaces incapable of healing.

We have to add, also, to the injurious effects resulting from pus production the possibility of amyloid degeneration of the arteries and the viscera; for modern pathology has recognized prolonged suppuration as one of the causes of this grave and obscure affection.

The conclusion seems, therefore, to be forced upon us that the secretion of pus is not only useless and wasteful, but that it is positively injurious.

It is desirable that the surgeon should recognize these truths, and assume it as a duty not only to favor rapid union wherever it is feasible, but to avoid suppuration as much as possible, and to arrest it always as soon as he can, keeping in mind the fact that the formation of pus involves the expenditure of vital force just as much as the construction of tissue.

The only exception that could be taken to the conclusion as to the uselessness of pus is the possible aid that it may afford in eliminating dead tissue or other solid foreign matters from the organism by way of abscess, and this subject we will next consider.

CHAPTER VIII.

Abscess.

The study of pus, by giving us an insight into its nature and mode of production, leads necessarily to the subject of *abscess*. In the various forms in which this surgical disease presents itself, it is of very common occurrence. It is always of interest, especially as to its causes and diagnosis; it is generally remediable, and, while often trivial in extent, is not infrequently of grave importance.

An abscess is a cavity containing pus formed in the tissues, and, it may be added, at their expense, and with the general purpose of eliminating some foreign or irritating material.

The festering that follows the lodgement of a splinter under the skin is a typical example of a superficial abscess; and the collection of pus that so commonly forms in the sheath of the psoas muscle, in consequence of disease of the vertebræ, is an example of a deep abscess.

When sufficient provocation has been offered, pus forms in the substance of the tissues by the same mechanism we have already observed in the repair of open wounds. The exciting cause, whatever it may be, provokes afflux of blood to the center of excitement; the distended capillaries give forth liquid exudation, which coagulates into plastic lymph; in the plastic lymph cell proliferation begins, and goes on to the formation of pus; the pus, as it collects, forms a cavity for itself, and the result is an abscess.

We have to remark concerning the phenomena which attend the formation of an abscess that most generally they occur in moderately rapid succession, and are attended, in a greater or less degree, by pain, heat, swelling, and redness, the latter not always showing itself upon the surface; and that evidences of *constitutional disturbance* may also be present, most frequently, in the shape of *fever*. Under these circumstances the term "inflammation" is very generally applied to this process of abscess formation. It is said to be accompanied by "inflammatory excitement." The liquid exudation is spoken of as "inflammatory exudation." The abscess is styled an "*acute abscess*," and the pus formation is regarded as the outcome of the "inflammation."

I beg you to notice that in this use the terms inflammation and inflammatory excitement are mere modes of expressing the fact that the process is attended by pain, heat, redness, and swelling, and that these terms are mainly employed to avoid circumlocution. They have in this connection positively no other significance; they convey no additional meaning as to the causes or mechanism of pus formation in abscess. This is rendered evident by the fact that there is a large class of abscesses known as *cold abscesses*, which form in the tissues without any pain, heat, or redness whatever, and with only the mechanical swelling that results from the accumulation of pus. I call your attention to this use of the term "inflammation" because it is habitually employed in a vague sense and in a loose manner that tend only to add obscurity to an otherwise simple statement. I will endeavor at another time to explain more precisely its meaning.

It might be asked here, when afflux of blood takes place deep in the tissues with exudation and organization of plastic lymph, "Why should the result be pus formation instead of 'adhesive inflammation,' which is the equivalent of the 'primary adhesion' that takes

place in a surface wound?" The answer is that when the injury causing the afflux, etc., has not been severe enough to cause death, or very severe lesion of tissue, "adhesive inflammation," ending in repair of the injured tissues without pus, does, in fact, take place—begetting a result identical with that by which the subcutaneous consolidation of a divided tendon is accomplished. For example, a moderate contusion or puncture usually, after a few days' soreness, gets well without further pain or trouble. But if any portion of the injured tissue has been deprived of life, then pus formation seems to be the inevitable outcome of the afflux and exudation. The death or fatal injury of a portion of tissue seems to be the most common provocation to pus formation in the depth of the tissues; and the floating out or elimination of the dead or injured tissue seems to be the object of the abscess which results.

Meanwhile, we have to note simply that an *acute abscess* is one that forms more or less rapidly, and is liable to be accompanied by pain, heat, and redness, as well as swelling; that in a *cold abscess* these features are absent, except swelling; and that in both constitutional disturbance may be present, but in different forms and with a separate explanation for each, which will be given hereafter.

When pus is developed in the depth of the tissues in the manner just described, these latter suffer both from its presence and pressure; muscular fibers are broken down; those of connective tissue give way; capillaries and nerves are first put upon the stretch and then ruptured. The stretching of nervous filaments explains the steady *aching* that belongs to forming acute abscess, and their rupture the sharper, sudden, darting pains that occur at intervals. In this manner pus forms a cavity for itself.

The forces by which this end is accomplished are, 1st, the exaggerated afflux of blood to the part, proved

by the *pulsatile* character of the pain, and evidently derived directly from the heart's impulse; and, 2d, the irrepressible tendency to cell germination provoked by the liquid exudation which is being constantly sweated out through the walls of the distended capillaries.

I have said that a collection of pus, or abscess, may form in a non-vascular tissue like epidermis, cornea, or cartilage. That the tissue-cells, nourished by the exuded juice from the nearest capillaries, when under the irritation of injury, are stimulated to proliferation and simply revert to their embryonic condition. Now, in their embryonic condition these tissues were nothing more than plastic lymph full of leucocytes; and leucocytes, as you know, are identical with young pus corpuscles. So that an abscess in the substance of cartilage, we will say, is, in fact, little more than a local reversion to the embryonic condition of the cartilage.

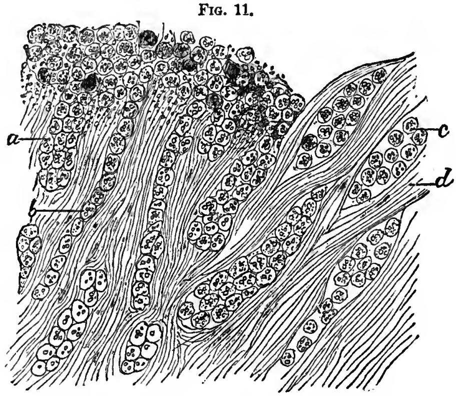
Thus the affected non-vascular tissue simply reverts for the time to its embryonic condition.

Any loss of substance of non-vascular tissue resulting from the pus formation is replaced, not by the original tissue, but by connective tissue.

In an experiment an incision was made upon the cartilage of a rib in a dog, and a portion of the cartilage removed, leaving a saucer-like cavity. Some days later the dog was killed and a thin slice taken from the cartilage across its length, involving at one end the point of loss of substance. When this was placed beneath the microscope it was found that the cells of the cartilage had begun to proliferate in an effort to replace the loss of substance, and that the cells nearest to the bottom of the saucer-like cavity had entirely replaced the intercellular substance of the cartilage, and presented the appearance of young connective cells or leucocytes touching each other on all sides and ready to undergo developement into connective tissue. The microscopic appearances by which this change is effected are represented in Fig. 11.

It is the rule in cartilage that lesions of its substance are replaced by connective tissue. Fracture of

Fig. 11.



Inflamed cartilage. (Cornil and Ranvier.)

the cartilage of a rib is healed by bony callus, into which the new bond of connective tissue has been converted. Articular cartilages, when a joint disease does not go on to suppuration, are replaced by newly formed connective tissue, which constitutes the medium of what is called *fibrous ankylosis*.

I would have you recognize, gentlemen, that these phenomena to which I am asking your attention are, in fact, the phenomena of inflammation, for the processes by which injury is repaired are indentical, up to a certain point, with the processes of *inflammation*. But there are some phases of the inflammatory process in which its object—the repair of injury—is unattainable, and here we encounter the phenomena of "destructive" inflammation taking the place of the "constructive" or reparative process by which we are occupied at present. The various forms of "destructive" inflammation, their causes, and the means by which destructive inflammation may be prevented and remedied, will occupy us hereafter.

When a cavity containing pus—i. e., an abscess—has

formed in the tissues, what is liable to come of it? Several results may follow. The most common is for the cavity, as it enlarges, to approach the external surface of the body, or one of its hollow viscera, and by its pressure to cause, first, distention and then ulceration of the tissues subjected to pressure, and, finally, for the contents of the abscess to be discharged through the opening thus made. In common language, the abscess forms, and then discharges itself. Or it may burrow or travel beneath the surface, advancing in any direction in which there is the least resistance. Or the abscess may cease to increase in size; it may become stationary, and so continue, as a *chronic* abscess. Or, again, in rare instances, its contents may disappear spontaneously, the abscess having undergone cure "by absorption."

Of these results, the first—a so-called spontaneous discharge—is by far the most common. It may be considered, indeed, as the natural termination of an ordinary acute abscess. Of this variety of the disease a common boil will serve as an example. This is, in classical language, called a *phlegmon*, a term which is applied to a hot, red, inflammatory swelling tending to suppuration—as distinctive from a *cold abscess*. Its symptoms are too familiar to require description.

With the discharge of a boil escapes, also, a small mass of harder substance called its *core*—a soft, solid, yellowish material, which seems to represent the climax of the inflammatory effort. It will repay us to study a little carefully the nature of this substance.

What is the core of a boil? It was formerly supposed to be a clot or coagulum of fibrin formed from the pus; and the pus itself was regarded as a spontaneous collection of "corruption," by means of which some poisonous material, some "peccant humor," was to be eliminated from the organism. The popular corollary that "boils are healthy" flows naturally from this proposition. But organic chemistry teaches us that the

core of a boil can not be a clot of fibrin, as none of this proximate element can be detected in any of the varieties of pus; and the microscope clearly shows us that it is in reality *a little ball, made up principally of threads of the yellow, fibrous element of connective tissue*, or whitleather (one of the simple tissues in our bodies, and that which, after bone, resists putrefaction the longest), with numbers of pus-cells in the spaces between its threads. Mingled with these, some half-dissolved fasciculi of white fibrous tissue and altered red-blood globules may also be recognized.

This histological demonstration of the true nature of the core of a boil, although a small affair, is, nevertheless, of much pathological significance to us, for it gives us a clew as to *why the little abscess formed*, and at the same time affords an explanation of the cause of abscess formation in general. Thus, the core was the result of the death of a small mass of connective tissue—a veritable sudden *necrosis*, just as though a piece of bone had died, which, we know, often happens. This little mass of dead substance, acting like a splinter, or any other source of irritation suddenly inserted among the living tissues, serves as a starting-point of pus formation, aroused, apparently, for the sole purpose of getting rid of it. The pus finds its way out by *ulceration*, and carries with it the dead mass of tissue, or all that remains of it undissolved, as the core of the boil. If you ask, "Why did this little mass of connective tissue die?" I answer, Through some temporary defect in the quality of the blood by which it was rendered unfit for the nutritive wants of this portion of tissue; by what is popularly, and in this case correctly, called "poverty of the blood." That the defect lies in the blood, or is otherwise of central origin, is rendered probable by the fact that boils seldom come singly; and that their tendency to form is pretty certainly interrupted by certain drugs which improve the quality of the blood, such as arsenic, the hy-

pophosphites of lime and soda, and the sulphide of calcium.

One of the most frequent causes of pus formation in the depth of the tissues is thus exemplified by the boil: the presence of a foreign substance, a splinter, a local death of tissue acting as an irritant, which is to be got rid of—to be floated out; and *this is accomplished by the collection of pus, and the ulceration which it occasions.*

I will remark here that the occurrence of *ulceration* is always effected by a mechanism similar to that which is observed in the spontaneous opening of a boil. The advancing tumor presents, at the center of the surface redness, a more prominent point, where the color of the skin becomes purplish or livid. The skin is evidently also growing thinner, for the yellow tint of the pus soon becomes recognizable through it. In this stage an abscess is said to be "*pointing.*" Shortly the thinned integument gives way, and the pus exudes through the opening. The cause of this behavior of the skin is simply that the blood-vessels by which it is supplied from beneath have been obstructed by the pressure of the enlarging abscess, or have been actually ruptured by extreme stretching, and the area of skin, thus deprived of its blood-supply, slowly dies. It dies by particles, or molecules, piecemeal. The dead particles are added to the contents of the abscess.

Under all possible circumstances this molecular death is the essential feature of the process which we call ulceration, and its immediate cause is defective supply of blood. In short, ulceration is molecular death of tissue caused by failure in its nutrition.

It may be that insufficient supply of nervous influence is also added to the vascular deficiency; and in some cases the bad quality of the blood, or the blighting effect of a virus, may, without further aid, start, and keep up, the ulcerative process, as in some phases of syphilis and phagedæna.

The exciting cause of a boil may be accepted as a type of the most frequent source of origin of abscess formation. To initiate the process it is not necessary that a portion of tissue should be actually dead; it is sufficient that it may have become so altered by disease or injury as to act as an irritant to the tissues around it. The little, flocculent, curdy masses often seen escaping from abscesses with the pus, especially from those of scrofulous or tubercular subjects, where the general condition of the patient is poor, and the pus consequently thin and watery, are either little aggregations of pus-cells or altered tissue, sometimes tubercular matter—little cores, in short, as of boils.

In *chronic* and *cold* abscesses the pus corpuscles have often a pallid, dropsical appearance, and sometimes their nuclei can not be made apparent by adding acetic acid; these corpuscles have long since ceased to live, and are, in fact, beginning to undergo solution. The serum of this variety of pus is consequently rarely transparent; it is generally turbid. With these water-soaked pus-cells others are found in a condition of fatty infiltration.

In pus from abscess of the female breast during lactation, milk globules may be found, and in these, as well as in abscesses of lymphatic glands, cells of pavement epithelium from the ducts, and also glandular cells, are often present. If we knew more of the subtile processes of organic chemistry carried on in the tissues and fluids of our bodies, we should doubtless find many products, derived from chemical changes in these unstable albuminous compounds, capable of acting as local irritants, and of causing abscess.

Even thinner and paler than the pus of a cold abscess is that from cavities containing dead bone left behind after abscess has failed to eliminate it; here we find, sometimes, drops of oil from dissolving marrow, and minute granules of osseous detritus, which can be felt as grit between the fingers. Under these circum-

stances, if an operation for the removal of the dead bone is not feasible, the injection of dilute sulphuric acid has proved effectual in dissolving it out. Careful scrutiny of the pus discharged from an abscess may, in any case, therefore, throw light upon its pathological significance, and suggest appropriate remedies.

The circumstance of textural death, or of change in chemical or vital qualities, under the multifarious unfavorable conditions which affect the blood and nervous centers so as to disturb the equable interchange of material which belongs to normal nutrition, is undoubtedly the most fertile cause of abscess. We have seen it acting as the cause of one of the simplest forms of the disease—boil, or furuncle; under the intensified effects of similar evil conditions, death of tissue may take place on a larger scale—as in the more serious disease known as *carbuncle.*

In carbuncle, the mass of superficial fascia that undergoes death, although in most cases not larger than the palm of the hand, is sometimes much more considerable. I have seen it extend to the area of a square foot. The dead tissue becomes hard and sodden by infiltration with exudation of apparently defective quality, which seems at first incompetent to excite cell germination and pus formation, for its expulsion takes place with great and prolonged effort, which not infrequently places life in danger. In this disease the tendency to local death is slow to limit itself, and the formation of a cavity lined with granulations, as in abscess, which is the outcome of the vital effort to eliminate the dead tissue, is equally slow; and sometimes it fails entirely.

In the more common surgical disease known as *phlegmonous erysipelas* the superficial fascia dies in still larger quantity. In this grave affection the blood has become so much altered by a specific poison as to prevent the ordinary sequence of symptoms of the reparative process with which we are familiar. There

is exudation, and also generation of leucocytes, and pus formation in an imperfect way, but there is no effort at forming granulation tissue, at least in the earlier stages of the disease. Consequently, *no barrier is constructed to limit the indefinite diffusion of the pus which is being produced.* Hence, as no cavity is formed with limitary walls, the term abscess is not properly applied to this diffuse form of pus production; it is usually described as *unhealthy or diffuse suppuration of connective tissue.* The essential feature of this form of disease is necrosis or death of connective tissue, a consequence of poison in the blood; and this poison is potent enough (at least until the quality of the blood is renewed) to prevent repair in the usual way—i. e., by tissue formation. In this respect it acts like the poisons we have already noticed, and others which we have yet to study.

From a pathological point of view, phlegmonous erysipelas presents but two cardinal features: local death of tissue from the action of a blood-poison, and waste in the shape of pus. By free incision of the overlying integument we can usually cut short the morbid process and afford opportunity for the dead connective tissue to be thrown off, and give free scope to subsequent repair by granulations as soon as they can form, meanwhile renewing the blood by iron, quinine, concentrated food, and stimulus. I have introduced this subject at the present time in order to define the nature of abscess more clearly as distinguished from "diffuse suppuration."

To illustrate further what we may call the *eliminatory* cause of abscess—i. e., where there is something to be got rid of—we see an example of it occasionally in a stump, after healing, where a silk ligature has been left inside through oversight. After a fortnight of annoyance, with redness and swelling and pain, finally an abscess points, a dischage of pus takes place, floating out the cause of all the trouble, and then permanent

healing promptly follows. I have seen the same symptoms result in the elimination of a piece of dead tendon, or bone, which had been slow in separating.

In like manner calculous formations within the body sometimes are eliminated; stone formed in the bladder has been known to find its way out through an abscess in the groin; renal calculi not rarely cause abscess pointing in the loins; and concretions from the gall-bladder, the prostate, the salivary glands, and tonsils have escaped by a similar process. Foreign irritants—such as splinters, pieces of clothing, etc.—carried into the body by bullets, are eliminated by abscess, of which there are numerous examples. The subcutaneous injection of the bichloride of mercury, advocated by Lewin, of Berlin, in the treatment of syphilis, although effective, has not found favor, because painful abscess so commonly follows the puncture. Irritating and poisonous materials carried by lymphatic vessels into the glands (these organs acting physiologically as filters) explain the frequency of glandular abscess, whether acute, as in the sympathetic and virulent buboes, or chronic, as in scrofulous affection of the cervical glands.

Finally, I will mention the multitudes of little abscesses of the skin which give its name to the suppurative stage of small-pox, each one of which has been provoked by the presence of a minute disk of dead true skin killed by the variolous poison, and has for its object the casting off of this tiny slough. A similar explanation may possibly exist for all pustular eruptions.

In regard to this eliminatory feature in the ætiology of abscess, which will be still further confirmed, do not allow yourselves to infer that it is in any degree inconsistent with what I have already asserted concerning pus—that this fluid is of itself innocent, and never the vehicle for the elimination of poison from the system. It may aid mechanically in floating out tissues killed by poison, or otherwise; but it is not a carrier of poisons out of the system in any other sense. Pus is never

truly entitled to its popular synonym of "corruption" except when accidentally polluted by admixture of a virus or of material foreign to its own constitution, or when actually dead and decomposing.

On the whole, then, I think we must admit the truth of the conclusion expressed by Robin: "*Pus is formed in the interior of our tissues when the necessity arises for the expulsion of some foreign substance, whether introduced into the organism from without, or resulting from the death of a portion of solid tissue from within.*" (*Op. cit.*, p. 378.)

In corroboration of this view, I may cite the modern explanation of the nature and causes of what were formerly called "*metastatic abscesses*," a very interesting variety of the affection. These abscesses were so called because some pre-existing disease was supposed to suddenly change its seat, or to multiply itself by translation to a distant part of the body. So-called *metastatic* abscesses are of very common occurrence. They are found most frequently in the lungs, for reasons to which I have already alluded, but they may form in the liver, spleen, kidneys, or elsewhere among the tissues. While the doctrine of "purulent infection" was in vogue, the abscesses so often found in the lungs were ascribed, as I have already explained, to the absorption of pus and its translation, or metastasis, to the internal organs. But Virchow, Professor of Pathological Anatomy at the University of Berlin, brought forward, in 1852, an entirely new explanation of the meaning of these abscesses, demonstrating that their cause is in reality identical with that which we have assumed to be the cause of other abscesses—namely, the presence of foreign material plugging up the smaller blood-vessels; and that the pus formation is an effort for the elimination of this foreign matter. Virchow's observations and experiments have been extensively repeated, and confirmed. His doctrine that the formation of clots in the larger vessels, and the subsequent plugging

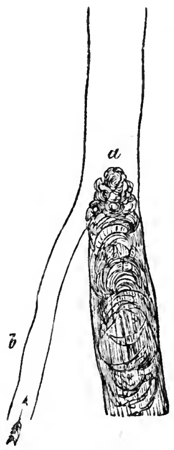
of the smaller vessels by these clots, or by fragments detached from them and carried by the torrent of the circulation into vessels small enough in caliber to be plugged by them—the doctrine of *thrombosis and embolism*, as it is called, to save circumlocution—is now universally received. The discovery of Virchow is regarded, and justly, as one of the most important advances in the pathology of our day.

A thrombus is most frequently a coagulum or clot of blood which has formed in a blood-vessel from any cause, generally from some poison in the blood itself. In a perfectly healthy condition of the body the thrombus is promptly organized into connective tissue and becomes continuous with the walls of the vessel, the caliber of which is consequently more or less completely obliterated. It undergoes, in fact, precisely the same changes as the clot that forms in an artery after its ligature. According to Rindfleisch, the clot formed after ligature "assumes the character of a connective-tissue plug, which appears to be more a portion of the surrounding connective tissue, as well as of the wall of the vessel, than a part of the blood." ("Histol. Path.," p. 192.)

When the blood is not in a sufficiently healthy condition a thrombus may fail to develop into connective tissue, and is liable to break down into detritus, or become partially dissolved into a soft, solid material resembling pus. This material is liable to be washed away by the blood-current and carried into the general mass of the circulation. On reaching the right side of the heart it is conveyed thence into one of the lungs through its pulmonary artery, and, borne along from the larger into the smaller ramifications, finally reaches a smaller branch, through which its bulk will not allow it to pass, and there it remains—wedged fast. The circulation in the obstructed pulmonary vessel is thus arrested more or less entirely, and usually some coagulum forms beyond the plug. This plug is called an *embolus*, and the condition I have described *embolism*.

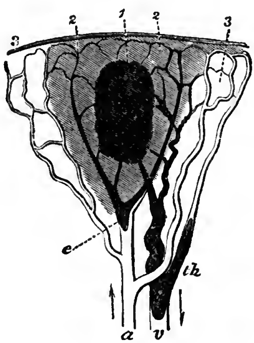
Different results are liable to follow this accident, which may take place under a variety of circumstances, some of which we shall encounter in connection with the subject of gangrene; but only one of them concerns us at present—namely, that the plug of foreign material thus lodged in the lung tissue very frequently excites suppuration, and the result is an abscess of the variety formerly called metastatic. Fig. 12 represents some ex-

FIG. 12.



Thrombus in a vein.

FIG. 13.



Hæmorrhagic infarction. (O. Weber.)

treme branches of the pulmonary artery occupied by an embolus, with a more recent coagulum filling the still smaller ramifications beyond it—a condition the Germans call "red infarction." The adjoining figure shows the original coagulum, which has extended as far as the nearest collateral vein and projects somewhat into its cavity. It has evidently grown by accretion, through deposit upon it of fibrin from the passing blood-current. Now, I trust you will not find it difficult to conceive that, if the substance of this thrombus should soften and break down, its fragments would fall

into the returning venous current and be disposed of ultimately in the manner I have described.

This explanation accounts for the so-called metastatic abscesses of the lungs, but not for those often found, in bad surgical cases of blood-poisoning, in the spleen, liver, and other organs and tissues supplied by the *systemic* circulation. Here the broken-down material of the thrombus must have passed completely through the lungs and reached the left side of the heart [or the "red infarction" formed beyond the original embolus has also broken down and followed the same course]. Billroth asserts that it has been proved by experiments —namely, by those of Otto Weber (see "Hand-Book of General and Special Surgery," edited by Pitha & Billroth, vol. i)—"that certain emboli, principally little flocculent masses of pus, can traverse the pulmonary capillaries without hindrance, reach the left heart, pass into the systemic circulation, and finally lodge in the spleen, liver, kidneys, or any other organ of the body, and there become the cause of abscess." ("Elements de Path. Chirurg.," Paris, 1868, p. 395.) Rindfleisch also says: "It has been established by the experiments of O. Weber that smaller emboli can pass the capillary system of the lungs in order to remain sticking in the narrower capillaries of the kidneys."

How coagula or thrombi are constantly liable to form in the neighboring blood-vessels as a direct consequence of an injury, a contusion, or a crushed limb, for example, or of the pressure of the swelling of injured parts around a wound, causing obstruction of the circulation; and how, if the wound takes on a bad condition, these coagula are liable to break down, form emboli, and cause internal abscess, we shall inquire further hereafter. But, before we drop the subject, I am anxious that you should recognize that the embolism which, as we have seen, causes internal abscesses in surgical cases which do badly, plays only a subordinate part; the poisonous influences which affect tissue life, which

cause a clot to break down instead of organizing, or prevent the process of repair from going on to tissue formation, are the primary and real sources of interference with the healthy healing of wounds. I would have you notice, finally, that *every abscess provoked by embolism has for its object the elimination of the embolus, however hopeless the effort may be.*

In seeking an explanation of the causes of abscess formation, we find that there is a class of abscesses, generally called "*sympathetic*," which form near diseased joints, in the neighborhood of an inflamed urethra, or of any established focus of inflammation, but not near enough to form a part of the existing textural excitement.

A case of hip-joint disease which runs its course without the occurrence of an abscess of this kind is rather exceptional. Perineal abscess occurs in stricture of the urethra, in some cases, without any appreciable connection between the stricture and the abscess sufficient to account for it. In stricture of the rectum, abscess not infrequently forms below the point of narrowing. The formation of an abscess near a healthy joint has even been assumed to indicate approaching trouble in the joint. [Holmes Coote, art. "Abscess," in Holmes's "Syst. of Surgery."]

It has seemed to me that there is enough evidence to justify us in attributing these "sympathetic" abscesses, certainly in some cases, to defect in the quantity or perversion of the quality of the nerve-force which should be supplied to the tissues. Dermatologists have taught us that certain skin affections, hitherto obscure in their origin, are certainly due to defect in regular and normal transmission of nerve-force to the seat of the disease, and that they are curable by treatment based upon this knowledge of their cause. In *herpes zoster* affecting the skin in the neighborhood of the eye, through deranged function of the third branch of the fifth pair, which places the eye itself in great danger,

this organ has been saved by substituting the stimulus of electricity for the defective nervous supply. I once saw with Dr. Thomas Cock a young girl of fifteen, with meningitis from extension of suppuration from caries of bone in the middle ear, in whom the eyeball of the same side had suddenly assumed a shriveled aspect, with opacity of the cornea. It had the appearance of a boiled gooseberry. The child died, and, on examining her head, I found pus beneath the dura mater where it invested the anterior surface of the petrous portion of the temporal bone, just where the great ganglion of Gasser of the fifth nerve lies. The fibers of the ophthalmic division of the great nerve were bathed in pus, and rendered distinct by dissolution of the connecting tissue, so that I could count them. We may infer from these cases that disturbed or faulty nerve-supply is not confined to the skin.

There is no known explanation, other than reflex nervous irritation, for the peculiar and fatal ulceration of the duodenum, commencing in follicular abscess, that occurs in connection with burns of the surface of the body. Fatigue of the retina and muscles of accommodation of the eye, after prolonged reading by artificial light, is a cause of the little abscesses in the meibomian follicles at the edges of the eyelids, called "styes." The peculiar disturbance of innervation which arises, in both sexes, from want of normal exercise of the genital function is recognized as a cause of the abscesses in the sebaceous follicles known as acne; and it is proved by the disappearance of this follicular eruption after marriage.

I have described the manner in which pus collects in the substance of any of the organs of the body, and the distending forces by the aid of which it forms a cavity for itself at the expense of the tissues. When thus formed, this liquid tumor behaves in some respects like any other tumor of rapid growth which may have developed among the tissues. As the accumulating

pus-cells increase in number and require more room, they encroach upon the neighboring parts and push them aside, and press upon the blood-vessels which supply them—thus interrupting their function and causing them to waste away—and finally take their place. As the abscess increases in size, some of the tissues naturally resist its advance more than others, through their greater elasticity and ability to stand pressure and soakage. Thus, while the white fibrous element of the omnipresent connective tissue softens down rapidly into a gelatinous consistence, the yellow elastic fibers, as we have seen, remain unchanged, as also does the arterial tissue. In this manner it happens that the cavity of an abscess rarely presents even or regular walls. The finger, when introduced into it, through an incision to evacuate its contents, comes at once in contact with the velvety surface of the granulation tissue by which it is lined, but the finger recognizes also, very commonly, prominent bands or sharp-edged partitions which stand out in relief from its walls and project into its cavity. These latter often divide the interior of an abscess into several compartments, or loculi, which more or less freely communicate with each other. Bands are not rarely felt in an abscess of some duration, which stretch across, like isolated beams or rafters, from one side of the cavity to another. These, on careful dissection, aided by the microscope, would be found to consist mainly of yellow elastic tissue, and to contain blood-vessels in their interior. Their formation is a distinctly conservative effort, and the surgeon, as a rule, should be careful not to rupture these bands.

It is by a mechanism similar to that which I have described that pus makes its way through the tissues when it travels from one locality to another by what is called *burrowing*, or *undermining*. Here the process differs in no respect from ulceration. But we must add to this explanation the force of gravity, which, as an abscess grows large, exerts an increasing influence, for

pus rarely travels upward; nor must we lose sight of muscular action, nor even arterial pulsation, for both of these aid its advance, just as they assist the flow of blood in the veins. *Pus, as a rule, when it travels, tends to seek the surface, for the simple reason that in this direction there is usually the least resistance to be encountered.* If there should happen to be a dense aponeurotic expansion between the abscess and the external integument, as when a collection has formed among the muscles of the thigh, the pus may travel along through the looser connective tissue beneath the fascia lata, and ultimately reach the surface at a remote distance from its original point of formation. Erichsen mentions a case in which an abscess of the vertebral column finally pointed beside the tendo Achillis at the ankle.

Or, instead of advancing toward the surface, the collection of pus may find its way into one of the internal cavities. Abscesses of the abdominal walls occasionally burst into the abdominal cavity; or, when occurring within it, they often form adhesions with the walls of the intestinal canal, and discharge themselves by ulcerating into its interior. Laugier ["Nouv. Dict.," art. "Abcès."] describes a case of abscess of the axilla which caused death by discharging itself between the ribs into the cavity of the pleura.

An abscess which has formed beneath the *parotid* fascia will, almost invariably, find its way into the mouth within the angle of the jaw, even after an external incision has been made, because rupture of minute blood-vessels and melting down of tissue have created, by undermining, an easier route in this direction between the pterygoid muscles. An abscess of the ischio-rectal fossa often opens into the rectum, rather than through the denser integument of the buttock. Sir Astley Cooper mentions a case in which such an abscess burrowed down into the popliteal space.

In diffuse suppuration, where no barrier of granula-

tions has formed, there is, of course, unlimited burrowing, and the connective and adipose tissues of a whole fore-arm or leg may be consumed and its integument undermined. It would be irrelevant again to speak of this serious condition, but it is well to know that, under favorable circumstances, it may cease and change its character; granulations may appear and invest the surviving parts, and then the conditions of true abscess are again present: of *healing abscess as after evacuation*, for the tendency to repair rarely shows itself in diffuse suppuration until either free incisions by the surgeon, or still more extensive spontaneous sloughing of integument, have given vent to the discharge, and with it to the dead connective tissue. The appearance of granulations under these circumstances marks both the limit of destruction by burrowing, and the beginning of repair. I have seen the entire scalp separated in this manner from the layer of tendon and muscle beneath it, in phlegmonous erysipelas, and yet, by timely incisions and supporting treatment, the patient made a good recovery. This broadcast pus infiltration or diffuse suppuration rarely occurs elsewhere than in the connective tissue, and, as I have said already, it is always significant of some poisonous influence profoundly affecting the nutritive qualities of the blood.

The only striking exception to this statement as to blood-poison, if indeed it be an exception, is in the so-called "osteo-myelitis" of young subjects from sudden chilling, when sometimes the entire shaft of a long bone dies—the articular epiphyses alone retaining their life—and where the whole segment of a limb becomes permeated by pus. Chilling kills rapidly growing bones of adolescents, and is thus a cause of pus formation and abscess.

The large and rapidly formed collections of pus which occur in women after childbirth (under the influence of a peculiar condition of blood that belongs to the puerperal state), although designated as abscesses,

often manifest a tendency to diffusion. Just in proportion to the degree in which they limit themselves, they are likely to be recovered from.

I bring these several conditions purposely into contact in order to illustrate these characteristics of abscess, and I repeat that *in the typical form of this disease there is a barrier which, in a certain degree, limits the advance of the pus; in diffuse suppuration there is no barrier. But if a tendency to recovery manifests itself in the latter, the barrier appears.*

And yet true abscess does often travel, as we have learned, and sometimes even in a direction against gravity. The mechanism of this process will become shortly apparent.

Immediately outside of its limitary wall of granulations in every abscess there is a layer of connective tissue condensed by the pressure of the accumulating pus. In this there is invariably present a certain amount of plastic exudation in which cell-germination is going on, always with the purpose of repairing the damage that is being done. As the abscess pushes in any direction, this germinating layer always precedes it, gradually invading the tissue just beyond or outside of that already invaded. This external zone of tissue is usually hot, red, painful, and thickened by infiltration with the liquid exudation from distended capillaries. Outside of this again there is another, wider zone of simple œdematous infiltration—the result of obstruction of the circulation at the inflammatory focus.

An imaginary section through an acute advancing abscess would, therefore, present at its center a collection of pus and broken-down tissue; outside of this an envelope of tissue condensed by pressure, full of distended capillary vessels, and infiltrated with exudation and germinating cells; outside of this again, a wider zone of simple œdema, diminishing gradually as the surrounding healthy parts are reached. When, therefore, a deep abscess is approaching the surface of the body,

the surgeon, in feeling for fluctuation, which is its most characteristic and surest diagnostic sign, will also recognize the presence of *œdematous infiltration of the tissues between his fingers and the collection of pus. And this superficial œdema is usually a diagnostic sign of deeper pus—a sign only inferior to fluctuation.*

An acute abscess of the liver tending toward the convex surface of this viscus would give rise to local excitement and alteration in its peritoneal investment, causing adhesion, over a limited area, to the peritonæum covering the diaphragm. The two layers of serous membrane would become identified, in fact, with the walls of the advancing abscess. Presently, in consequence of the increasing pressure of pus in the abscess, and consequent interference with their blood-supply, the adherent layers of peritonæum begin also to give way at some point of least resistance, and the muscular tissue of the diaphragm becomes involved in the advancing line of inflammatory exudation. The diaphragmatic reflexion of the pleura is next invaded, and becomes glued fast to the pulmonary pleura, *so that the air-cells of the lung form, ultimately, the point of least resistance to the advancing collection of pus.* By this route and by this mechanism an abscess of the liver may burst into a lung, and its contents be expectorated through the air-passages.

Most authorities, in describing abscess, recognize a membrane specially formed for this purpose as inclosing the collection of pus, and it has been usual to speak of this as *pyogenic*, or pus-producing; such a formation has been described as an actual membrane, produced, in the language of Mr. Coote, by the "organization of coagulated fibrin." [Holmes's "Syst. of Surgery," vol. i, art. "Abscess."]

Now, I can find no evidence of the existence of any such membrane, unless the name be applied to the layer of granulation tissue which forms as a conse-

quence of the effort to limit an advancing abscess. This, which can not be properly called a membrane, is identical in all respects with the granulating surface which forms upon recent wounds when not brought together for primary union.

Granulating surfaces can not properly be regarded as membranes organized for the production of pus, for the pus (in the shape of germinating leucocytes and liquid exudation) is produced before the so-called membrane; and the flow of pus ceases as soon as the granulating surface has fulfilled its purpose by cicatrizing, or uniting with another granulating surface.

Knowing, as we do, that pus is an accidental, purposeless incident in the process of repair, we can not accept the doctrine that a membrane is systematically organized for its especial production. But it must be confessed that in chronic and cold abscess there is a uniform, velvety, vascular surface presented by the walls of its cavity, resembling, to the unaided eye and to the touch, the interior of the stomach, which is highly suggestive of the idea of a lining membrane. An eminent French authority [Denonvilliers, "Compendium de Chirurgie," t. i], anxious to maintain the doctrine of which his countrymen (Delpech and Dupuytren, following Hunter and Home, in England) were ardent supporters, confesses, nevertheless, that he has always failed in his attempts to dissect off this membrane, and thus to demonstrate its existence with certainty.

This soft, vascular material, which can be readily scraped off by the scalpel as a pulpy mass, is a surface of granulation tissue and nothing else. It was originally formed for a reparative purpose, the accomplishment of which has been prevented. Its usual aspect has been more or less modified by pressure and maceration in pus, which has also undergone change from age. *This is the only true pyogenic surface, and it is obviously not a membrane.* The elucidation of these

facts is another of the benefits we owe to the use of the microscope in surgical pathology.

As a normal feature in every acute abscess, the layer of granulations by which its walls are lined *is ready, as soon as the collection of pus has escaped, to unite and grow together by its opposing surfaces, as in union by secondary adhesion.*

If the evacuation of the pus, whether spontaneously or by the surgeon's aid, be long deferred, the abscess is no longer acute; it has become a chronic abscess, and the delicate layer of tissue which lines its walls, balked, for the time, of its constructive purpose, may have undergone retrogressive changes. But, if the surgeon can bring about an improved condition of the patient's general health (which is always necessary where a chronic abscess exists), and at the same time secure thorough drainage after it has been opened, the effort at repair may be renewed and a good result attained.

If we except the non-vascular tissues, abscess formation always takes its origin in the universally present connective element. When seated in muscle, or in glandular substance, it is in the connective-tissue parenchyma that the process always begins. The peculiar substance of muscle or gland may become altered and provoke pus formation; but its earliest inception is marked by proliferation of leucocytes in the meshes of the parenchyma. Even in bone, the delicate lining of the cancelli, or the medullary membrane proper of the shaft—both connective tissue—lend themselves, although unwillingly, to circumscribed, and also to diffuse pus formation—the latter being known as *osteomyelitis.*

Circumscribed abscess in the cancellated structure of bone manifests its presence by very severe, deep, boring, localized pain, worse at night, intermittent, attended by increased surface heat and tenderness, more rarely by external redness or swelling. Its diagnosis is to be reached by the process of exclusion. The use of the

trephine—as an exploratory operation if the diagnosis has not been certainly made out, otherwise as a directly curative procedure—offers the best prospect of relief. Even in case of simple chronic inflammation, or cyst of bone, benefit has followed the trephine. As I have already intimated, these abscesses, when they contain solid pus, have been mistaken for deposits of tubercle.

The *symptoms* of an ordinary acute abscess, considered in view of diagnosis, may be described as follows: First, a sensation of *soreness, aggravated by pressure and localized*—let us say, for example—deep in the thigh; then *positive pain*—continuous, increasing, throbbing. After a time this pain changes somewhat in character; it becomes tensive and lancinating, but perhaps not quite so constant.

Beginning soon after the soreness and pain, there is obscure *localized swelling*, gradually increasing *heat*, and more or less surface *redness*. About the period when the pain changes its character the general redness, if present, may become less vivid, but a positive increase of swelling is perceptible at its center—the "pointing" already spoken of—and, coincidently, *rigors*, or a *well-marked chill*, denote the crisis of pus formation. These are the usual symptoms which indicate that suppuration has taken place. In other words, lancinating or darting pain, and chill or rigor, occurring after some days of localized continuous aching and throbbing, are the diagnostic signs of abscess formation. Fever of the traumatic type may be present.

After these symptoms, if the abscess is not too deeply situated, fluctuation may be usually discovered on palpation. If not, the persistence of localized swelling, with the presence of œdema, renders the existence of deep pus more than probable. After a little delay it may come nearer to the surface.

Œdema is recognized by the slight surface depression that remains for a little time after firm pressure by the end of a finger; this is called "pitting."

Fluctuation, as the word signifies, is a sensation as of a wave of fluid beneath the surface. When the amount of fluid is small it is to be detected by pressure and relaxation made alternately by a finger of each hand. When the amount is larger, several fingers or a whole hand may be employed. This is called "feeling for fluctuation."

The exploring-needle is another means of diagnosis applicable to all deep collections of fluid. An exploring-needle should have a deep lateral groove; and in this the pus appears as soon as its point has entered the cavity of an abscess, being forced out by the elasticity of its walls. The French employ for this purpose a minute capillary trocar, which is found in every surgeon's pocket-case. To this the "aspirator" of Dieulafoy, a most useful contrivance, has been lately added. It is simply an accurately made syringe with a stop-cock near its nozzle. This is closed and the piston raised, and a vacuum is thus created in the barrel of the syringe. When thus prepared, the nozzle is connected with a fine trocar, which is plunged into the suspected collection of fluid. The stop-cock is then opened, and, by the suction or "aspiration" that follows, the contents of the cavity are sucked up into the barrel of the syringe. When this is made of glass, the demonstration of the presence of pus and its withdrawal are accomplished at one and the same moment.

CHAPTER IX.

Abscess—(*continued*).

A COLLECTION of pus, accompanied at first by pain, heat, redness, and swelling, may cease to grow and gradually lose these symptoms, the surrounding parts becoming in a manner tolerant of its presence; this is a *true chronic abscess;* but it is not very common. In the vast majority of cases, if let alone, an abscess which has begun acutely will discharge itself sooner or later in the direction of least resistance. It may leave behind it, possibly, a sinus or a fistula, and to this the term "chronic" will be more truly applicable.

An acute abscess which has been left to discharge itself will not heal so promptly as if its opening had been judiciously anticipated by the knife; there will be more thinning and ulcerative destruction of integument, and a larger gap to be ultimately filled up.

But abscesses not infrequently form without any previous pain, heat, or redness whatever—a simple fluctuating swelling constituting apparently the whole disease; perhaps the collection of pus has grown so silently that it may have even been discovered by accident, having already attained a considerable size. This is the true *cold abscess.* Making its appearance thus, without any antecedent phenomena, a cold abscess is liable to be mistaken for an encysted tumor, or, if located in the groin, for a hernia.

The *causes of cold abscess*, and the mode in which it forms, are identical with those of the acute varieties of the disease, only the causes have acted more slowly,

without enough violence to occasion what are called inflammatory symptoms. Moreover, abscesses of this class are significant of some constitutional vice or acquired diathesis, by which the blood has been rendered unfit for proper nourishment of the tissues.

One of the most striking characteristics of cold abscesses is a tendency to travel. They also originate very commonly from disease of the vertebral column. For example, a *psoas abscess* originates from the lower dorsal or upper lumbar vertebræ, and follows down the sheath of the psoas muscle, which takes its attachments from the same quarter, and makes its appearance finally at the surface, in the groin or in front of the thigh. Cold abscesses are liable to form between the dense fibrous planes of origin of the transversalis abdominis muscle from the spinous and transverse processes and bodies of the lumbar vertebræ, and are hence designated *lumbar abscesses.* They are frequently, but not invariably, traceable to disease of bone as their source of origin ; and they sometimes, indeed not very rarely, get well under improved conditions of life and repeated tappings through valvular openings, or by means of the aspirator.

In a certain proportion of cases, as I have witnessed, after the bulk of a cold abscess has been reduced in this way, its contents have ceased to re-accumulate, and they have gradually disappeared by a process of *absorption.* This fact of the possible disappearance of cold abscess by absorption is well established, and should not be lost sight of. (See "London Medical Times and Gazette," 1858, for cases, and elsewhere.)

Absorption of pus would seem to be possible wherever the dead or altered tissue, which has provoked the collection of pus, is capable of being dissolved or of undergoing liquefaction. Or, in view of the experiments in which solid molecules of vermilion have been found in the interior of lymph corpuscles in circulation, taken up from granulating surfaces upon which very

finely powdered vermilion had been sprinkled, it may be inferred that even minutely divided insoluble substances may also possibly be absorbed.

The reason why absorption of pus takes place is pretty certainly an improvement in the quality of the patient's blood and in his vital force. An abscess of several years' duration has disappeared during a sea voyage. The more ordinary *local* remedies—tincture of iodine, blisters, and pressure, without change in condition of life, and improved hygiene—have been, in my experience, to say the least, inefficient.

But in *cold abscesses which have diseased or dead bone* for their source, so happy a result can not be anticipated. The possible existence of either of these causes for a given abscess—although it may be inferred from the presence of a fixed pain or tenderness at some point of the skeleton, or from the occurrence of deformity such as the angular projection in so-called "Pott's disease," or from the actual presence of particles of bone earth discovered in the pus dischaged—can not be regarded as absolutely out of the question, even when these signs are wanting. In cases of doubt, when the patient's general condition is fair and improving, careful tapping by a valvular opening, or partial evacuation by the aspirator, may be attempted. But, in view of the danger that so often follows of fatal hectic and wasting, *it is not wise to open a cold abscess of large size* under any circumstances except the following: (1) to save ulceration of the skin when spontaneous opening is inevitable; (2) where the abscess is causing great pain by pressure upon a nerve, or where it threatens to burst into a joint or into one of the great cavities; and (3) after it has been reduced to a very moderate size by previous tapping, which has been well borne, and the patient is gaining in health.

When an opening is justified by any of these reasons, a depending situation should be chosen for it, and *the incision should be free enough to prevent any*

portion of the contents of the abscess from being retained after the external air has once had free access to its cavity. This opening should be made with all the antiseptic precautions. If pus be retained in any degree after a cold abscess has been opened, it will tend to decomposition, and the sulphureted hydrogen given off is liable to be absorbed into the blood, or even a more dangerous septic poison may be generated. The surgeon has it in his power to prevent this by the judicious employment of systematic measures to insure drainage; by regular washing out with antiseptic solutions, in which the distention recommended by the late Mr. Callender may be employed; and by carefully applied antiseptic dressings.

The little almond-shaped *dermic abscesses* which form in the substance of the true skin, often of the face, in scrofulous children, belong to the class of cold abscesses. They are utterly insensitive, and travel often from the face, along the neck, to the surface of the chest, leaving unsightly scars. Their most successful local treatment is by evacuation and subsequent injection with pure alcohol, which, when associated with judicious general measures, seems to arouse a tendency to repair.

But it is in the lymphatic glands, especially those of the neck, groin, and axilla, that the surgeon has most frequently to deal with pus formation of the chronic variety. A painless, slow-growing, circumscribed, fluctuating tumor makes its appearance in the neck, usually of a young person in delicate health. It may pass for an encysted tumor—which, in some sense, it is; or possibly it is in such close contact with the carotid artery as to receive a partial impulse from the great vessel, and the idea of aneurism may suggest itself; but almost certainly it will prove to be a degenerated lymphatic gland full of pus. As to the details of its formation, this sort of tumor may not be strictly an abscess, but it is universally so designated. Its outer layers

of investment are sometimes so dense as to mask fluctuation, and such abscesses have been, not very rarely, removed as tumors.

These glandular abscesses have one feature in common which very decidedly affects the results of their treatment: they occupy localities in which constant motion is unavoidable. Thus, in the neck, the constantly recurring movements of the gullet and trachea in swallowing and speaking, and the hinge-like friction-producing movements to which they are subjected in the groin and axilla, tend greatly to aggravate diseased action and to retard healing—*for which rest is so necessary. Hence the frequency of sinuses in the groins and neck following abscess.*

Lymphatic glandular abscesses are justly attributed to scrofulous and tuberculous qualities of constitution, and require general rather than local treatment. Life in the open air, change of climate, good food and clothing, cod-liver oil, and the correction of unhealthy habits and unfavorable conditions of life, will be found to be the best remedies for the local ailment. The knife is not required except for the purpose of economizing destruction of skin by ulceration, when this result is threatened by slow and imperfect spontaneous opening. In this case an incision should be made of moderate extent, in the direction of a natural wrinkle of the skin and where it is thinnest; and also in a *depending* position, mainly for the purpose of preventing a large and unsightly cicatrix. Under favorable cicumstances I have known these abscesses to disappear by absorption of their contents; but this result is exceptional. Sometimes the pus-cells become infiltrated with earthy salts, and a shrunken mass of calcareous hardness remains to mark the seat of the abscess.

I have now mentioned the general varieties of abscess formation and their causes, with, perhaps, one exception. Sir James Paget has given the name of "*residual*" abscess to a collection of pus that results,

during a debilitated condition of the system, from the breaking down of connective-tissue neoplasm which had been organized in some former effort of repair. The essential cause of pus formation here is one already recognized, namely, a failure of vital quality in the cicatricial tissue, which gradually becomes thereby a source of irritation, and provokes an effort for its elimination.

The *treatment of acute abscess* comprises mainly rest and poultices, and what is styled by the French *expectation.*

We borrow many terms from the French in surgery, because their clever *finesse* often secures a better expression for the ideas we wish to convey. "Expectant treatment" is one of these: it implies patient waiting for indications, and avoidance of officiousness. While fluctuation has not yet become manifest, and there is a chance that the symptoms may not culminate in pus formation, and what is called "resolution," or "delitescence," is consequently a possibility, a warm poultice is still the best local application. Lead-water or opium in some form may be added. Anointing the part with mercurial ointment and then applying a warm poultice is an old and favorite practice, sanctioned by high continental authority, for locally inflamed parts. Billroth recommends this at present; it was a favorite remedy of Velpeau, when I was a student, to smear an inflamed part with mercurial ointment and apply a poultice over it. The idea of its efficiency is evidently derived in a great degree from the obvious good effects of mercurial applications in syphilitic inflammations—the specific character of which was not always recognized.

You need have no fear of causing suppuration by using poultices where it would not otherwise take place. Heat and moisture will not cause suppuration; but, when it is imminent and unavoidable, they certainly relax inflammatory tension, and promote it. If resolution without pus formation is a possibility, it will also certainly be favored by these applications.

The earlier an acute abscess is opened after pus has formed, the better will be its chances for prompt healing. After the evidence I have adduced as to the probable causes of abscess, it is obvious that we are assisting nature's intention in the way of elimination by giving the earliest possible chance for escape to its contents. By this course we economize time and suffering and save tissue.

In the language of Miller, an Edinburgh professor, remarkable for the elegance of his style, and the author of a text-book which was popular thirty years ago, "time, texture, and torture are all saved by the early opening of an abscess." For evacuating the contents of an abscess, a slightly curved, sharp-pointed bistoury, with a narrow, thin blade cutting on its concave edge, is preferable. Its point should be introduced perpendicularly to the skin, and, when the cavity of the abscess is reached, the opening is completed by rapidly cutting from within outward, *which pretty certainly gives less pain.* Where it is thought safer to introduce an exploring-needle, when the pus appears in its groove, then the point of the curved bistoury can be inserted in this groove, using it as a director. Where pus lies deeply, or an artery or nerves are close at hand, it is a better plan to etherize the patient and to use a scalpel, dividing the tissues more carefully layer by layer, and searching for the pus with a director or the finger, in the manner emphasized by Hilton.

For an abscess of any size the incision should be made at least large enough to admit the surgeon's index-finger. *It is a common mistake to make too small an opening—a mere puncture—and trust to squeezing and pressure to evacuate the pus. This is unsurgical.* As a rule, no pressure should be used to force out the contents of an abscess after the knife has been employed. *If the opening be large enough*, the spontaneous contraction of the walls of the cavity will effectually accomplish this result after a poultice has been applied;

if not, a probe-pointed bistoury should be inserted and the opening enlarged. An insufficient opening, by preventing collapse and contact of the walls of the abscess, constitutes an obstacle to prompt healing.

The same result will follow when the opening has not been made at a *dependent point* of the cavity. If any pocket be allowed to remain which can not readily and completely empty itself by simple gravity, there will be delay in healing, and, as a result, a possible sinus, which may require a second operation. *A depending opening from which pus may escape satisfactorily is a surgical necessity.* It is a mark of slovenly surgery to remove a poultice and proceed to make painful pressure in order to empty the cavity of an abscess. It should empty itself, otherwise a *counter-opening* at a really dependent point is indicated; or, if this is not feasible, means for drainage should be at once employed.

For tapping a cold abscess, where an aspirator is not at hand, the best plan is to select a point within an inch or two of its circumference, on the side opposite to that toward which the pus would naturally gravitate, and there make an incision through the skin large enough to admit a full-sized trocar into the subcutaneous fat. Then, rotating it like a drill, carry the trocar through the wall of the abscess, which at the same time is made to bulge toward the point of the trocar by very gentle pressure with the other hand. This pressure will cause the pus to flow through its canula when the trocar is withdrawn, and, if kept up steadily until one half or two thirds of the contents of the abscess have escaped and the canula has been withdrawn, no air will have entered its cavity. A probe should be always at hand in case the canula becomes obstructed by any of the flocculent, curd-like masses so often present in the discharge from these cold abscesses. Adhesive plaster accurately applied to the little wound, and a soft compress carefully adjusted so as to make equable

pressure over the whole abscess, and kept in position by larger strips of plaster or a bandage, complete the dressing.

The principal danger in opening large cold abscesses otherwise than in the manner I have described consists in the inability of the vital resources of the patient to repair so extensive a lesion. Cold abscesses are usually large, because they are painless and their growth is slow; so that relief is rarely sought until their size creates alarm. The amount of pus in these abscesses is in some cases very considerable. Professor Agnew mentions an instance in which he drew off nearly two gallons. The patient's capacity for undertaking the repair of such a cavity is already at a low ebb, as proved by the existence of so much chronic disease. The organism may tolerate the presence of a large collection of pus for a long time without any very serious symptoms, but, as soon as it is called upon for the more serious effort of organizing new tissue throughout an extensive surface, for the purpose of healing a great cavity, the lack of reparative power becomes manifest. The altered layer of granulation tissue already lining the walls of the abscess—the so-called pyogenic membrane of the old authors—deprived of the equable pressure of the pus by which its feeble circulation has been maintained, and entirely unequal to the effort of reorganization, dies. A grayish-yellow surface, with dark red, almost black patches, and here and there slate-colored gangrenous spots, results, and this yields a thin, serous, fetid discharge containing much dead matter, but very few leucocytes.

With this local failure of vitality the patient's general condition is in accord, all the symptoms indicating exhaustion. Within a day or two after the opening of the abscess a chill usually announces the inauguration of hectic fever; and, by the slow, wasting process of which this form of fever is the accompaniment, sooner or later life is brought to a close. There are cases in

which the free opening of a large abscess is followed at once by chill, intense fever, and speedy death. In a certain proportion of cases there is partial and ineffectual effort at healing. In this event the cavity of the abscess contracts, and continues, indefinitely, as a *sinus* or *fistula*, which, under exceptionally favorable conditions, sometimes gets well.

In the case of a lady of forty-five, whom I saw with Dr. Keyes, a lumbar abscess partially evacuated itself through the bronchial passages. Subsequently, after aspiration, a fistula resulted externally in the loins, and this, under the use of stimulating injections, got well at the end of two years.

Many years ago an unhealthy-looking, emaciated boy was brought into my wards at the New York Hospital with an enormous abscess of the haunch, just on the point of bursting, as indicated by the thinness and shiny redness of the skin at a sufficiently depending point. It had apparently followed a fall some months before. After consultation with my colleague, Professor Markoe, who was present, I made a free opening, and, after several pints of ill-conditioned pus had been discharged, a bucketful of tepid water was gently thrown into the cavity by means of a Davidson's syringe, so as to moderately distend it and thoroughly wash it out, and then it was allowed to drain off. The boy subsequently recovered entirely, with hardly a bad symptom.

In a case like this, the improved diet and nursing in a comfortable hospital ward, and the youth of the patient, are important factors in promoting so favorable a result—which was, nevertheless, so exceptionally rapid as to impress itself upon my memory.

I learned from Mr. Lister, when in Edinburgh, that he had in several instances, by the careful and thorough use of drainage-tubes and antiseptic dressings, succeeded in radically curing psoas abscess. He succeeded in keeping the pus sweet, and in steadily diminishing

its amount, as the cavity and the sinus which succeeded slowly consolidated. But, as he remarked, the treatment required great care and faithful perseverance for a long time, the intervals of dressing being carefully timed and the drainage-tube judiciously shortened as consolidation advanced.

Abscess in certain localities presents peculiar features which influence its treatment. When developed deeply in the throat, between the posterior wall of the pharynx and the bodies of the cervical vertebræ, a collection of pus may cause suffocation by pressure upon the larynx at its upper opening, or by suddenly bursting and filling its cavity. Several fatal cases are on record as occurring in this way. Here the ordinary mode of detecting fluctuation by the alternating pressure of two fingers can not be practiced, and a *post-pharyngeal abscess*, which presents itself as a soft, solid tumor, pushing forward the posterior wall of the pharynx, is to be distinguished from a soft cancerous tumor, which it simulates, by the resilience of fluid as felt by the extremity of one finger, and by making sufficiently forcible pressure to touch the surface of a vertebral body. It should be opened as soon as the diagnosis is clear.

A similar danger attends peritonsillar abscess, or quinsy, which occurs so frequently in the windy month of March. It sometimes tends to point posteriorly into the pharynx, and sometimes in front, and a point for opening can not always be detected. When such an abscess projects forward it is judicious to make a provisional opening in front, so as to secure beforehand an easy route for early discharge, always keeping in mind the proximity of the internal carotid trunk. Professor Agnew mentions the case of a medical student in whom "the abscess burst posteriorly, poured a torrent of pus into his trachea, and, before assistance could be rendered, he was dead."

Deep abscesses of the neck also demand early opening, lest they gravitate into the cavity of the thorax

and burst into the anterior mediastinum, as I have witnessed, or into the cavity of the pleura, or threaten interference with the larynx or trachea. Coote relates a case in which there was dyspnœa, with numbness of the arms and partial paralysis of the lower limbs. The evacuation of six to eight ounces of thick matter from a deep abscess of the neck was followed by relief to the suffocation and slow return of function to the limbs. Here, evidently, there was pressure at their origin upon the spinal nerves.

Mammary abscess during lactation is very common, and a source of great suffering to the mother and of danger to the child. Its usual cause is over-distention of the milk passages, through difficulty and delay in getting the infant to nurse. Just as soon as a collection of pus in the breast can be certainly detected it should be freely evacuated, because the extension of the abscess threatens more damage to the organ than the knife. Leeching, to relieve pain in these cases, is unwise, because it is exhausting to the lying-in woman, and, in the main, ineffective; and supporting the mamma by a sling of bunting and generous diet are especially necessary, applying pressure as soon as it can be borne and getting the patient into the open air. In opening an abscess of the breast the incision should be made always on a line radiating from the nipple as a center, to diminish the liability of cutting across milk ducts as well as blood-vessels.

Chronic abscess behind the breast has been mistaken for malignant tumor. It is difficult in its management, for sinuses are likely to remain after its opening, in consequence of the mobility of the chest-walls in breathing, and also of the mamma itself. Depending openings, carefully studied drainage, and support of the breast by adhesive plaster strapping, I have found most effective.

The necessity of early opening is illustrated by a case reported by Dr. Caton, of the North London

Hospital. [Lond. "Med. Times and Gaz.," October, 1878.] In this case an abscess of the axilla in a girl burst into the lung of the same side after having consolidated the pleuræ, and pus was expectorated. It was subjected to pressure, and ultimately got well.

Pelvic abscess is comparatively rare in the male. It occurs occasionally from perforation of the acetabulum in hip-joint disease, and still more rarely from suppurative inflammation of the sacro-iliac synchondrosis.

Abscesses of the abdominal walls and in the iliac fossæ are sometimes significant of intestinal disease. In the right iliac region especially the occurrence of abscess is suggestive of its possible origin in the connective tissue around the head of the cæcum (*perityphlitis*)—perhaps of ulceration of the vermiform appendix from impaction with foreign material. Professor Alonzo Clark once showed at the Pathological Society the appendix of a gentleman noted as a sportsman which was full of bird-shot. By watchful scrutiny of the local indications of pus formation in this region, and early dissection in the direction of œdematous thickening, or possible deep fluctuation, an abscess may be prevented from bursting into the cavity of the peritonæum. I am confident I have seen life saved in this way in several instances. But pus may form *beneath* the iliac fascia, in the iliac fossa of either side, generally in robust subjects, from a violent strain; at least this has been the character of several cases which I have observed. *Sub-fascial iliac abscess* is recognized by pain increased on forced extension of the thigh, which the patient keeps always semi-flexed, whether in the standing or recumbent position, and a tumor deep in the iliac fossa which sometimes projects below Poupart's ligament. With these symptoms, of recent occurrence, it would be right to seek for pus in the iliac fossa by approaching it from beneath Poupart's ligament in the course of the tendon of the *iliacus-internus* muscle, where it is about to join that of the *psoas mag-*

nus. By an incision beginning just below Poupart's ligament and opposite to the middle of its outer half, and carried through the fascia lata, aided by the finger and a director, an issue can be safely secured; and, in my experience, the relief has been immediate and satisfactory.

Cases are on record, where the patient has survived, in which intestinal worms, and even metallic quicksilver which had been swallowed, have escaped through the openings resulting from abdominal abscesses.

I have known ulcerative pyelitis to result in a *perinephritic abscess* which subsequently traveled down along the psoas muscle and presented itself beneath Poupart's ligament at the groin. In this case a globular tumor, presenting deep but distinct fluctuation in the site of the kidney, was mistaken at one period of the case for a malignant growth.

In a recent case presenting this latter feature, in a patient with excessive irritabilily of the bladder and intermitting passage of pus, I advised cutting down upon the kidney in the loin, with the view of establishing a lumbar fistula, to which the patient submitted. After exposing and incising the kidney substance, which was done by Dr. Keyes with the cautery knife of Paquelin, some ten ounces of pus were obtained. This was not a perinephritic abscess, but an abscess in the kidney itself.

In a case of perinephritic abscess in a gentleman of middle age, the collection of pus was very large, reaching beyond the median line of the abdomen and fluctuating so distinctly as to suggest imminent danger of bursting into the peritonæum. The patient was hectic. A slight prominence with deep fluctuation was detected in the site of the kidney, posteriorly. The aspirator was employed at this point three or four times, causing considerable reduction of the abdominal swelling, and then a permanent fistula was established, which discharged freely. The patient was ultimately sent to

the country, where, the fistula remaining open, he improved greatly in health.

In perineal abscess the probability of the escape of urine after its evacuation, and, in abscess near the anus, the likelihood of a resulting fistula in ano, should always be foretold to the patient.

In opening abscesses of the testicle the possibility of the subsequent protrusion of its secreting structure in the form of what is known as *fungus testis* is to be foreseen. This strange-looking protrusion is very likely to be mistaken for malignant disease, and the patient condemned to castration. But it is usually curable by the judicious treatment first recommended by Syme, of Edinburgh.

CHAPTER X.

Sinus and fistula.

I HAVE laid down the rule that the incision by which an abscess is opened should be made as nearly as possible at its most *depending* point, so that the pus may have a direct outlet; also that the incision should be large enough to give a free as well as a direct outlet. In an acute abscess, when these conditions are fulfilled, healing as a rule follows at once by contact and coalescence of the recently formed healthy granulations by which the inner surface of its walls is covered. But when these conditions are not met, when an abscess has an outlet which is too small, or situated at a point of its circumference which does not allow its contents to drain off entirely, then the pus remaining in the cavity of the abscess *prevents complete contact of its walls*, and, to employ a term in common use, "bagging" takes place, leading to necessity for a second opening. Entrance of air also brings about decomposition of the pus, with injury to the healthy character of the granulations, and their consolidation is delayed. The cavity of the abscess contracts, as it always does in a certain degree when the tension of its contents has been removed, from the contractile quality of the granulation tissue lining its walls, but it does not close entirely. The portion that remains open, being narrow and cylindrical in shape, and terminating generally in a somewhat expanded cul-de-sac containing the residual pus, constitutes the type of what in surgical language is called a *sinus*. The term *fistula*, which is used indif-

ferently with sinus, rather conveys the idea of a *pipe*, open at both ends.

Thus, a fistula in ano, taking its origin in an abscess which has formed in the ischio-rectal fossa beside the bowel, opening first externally through the skin, and afterward ulcerating into the gut, is at first a sinus, but, after the second opening, it becomes a typical fistula. The true fistula presents a generally cylindrical shape, and it not only has an external opening, but communicates by its other extremity with some internal cavity of the body.

There is hardly an organ or cavity of the body, the brain not excepted, which has not been the seat of sinus or fistula, as a consequence of wound, slough, or abscess. Bayonet thrusts, stabs, and bullet wounds frequently produce them; and so also when pieces of clothing and other foreign materials have been carried into the interior of the body by gunshot projectiles. When thus caused, it is easy to conceive how a long sinus may traverse fat, muscle, and aponeurosis, involving strata of different tissues in its course.

The causes which interfere with the consolidation of an ischio-rectal abscess illustrate the mechanism by which sinuses form and are kept up. The constant motion to which the part is subjected by the restless action of the neighboring sphincter muscles, and the constantly varying volume of the gut, prevent the quiescence necessary to insure healing. When a complete anal fistula has formed, with an internal as well as an external opening, another cause comes in play that keeps the canal from healing: namely, the passage through it of gas and other irritating matters from the bowel.

Sinuses are very apt to follow deep suppuration in the palm of the hand, buboes of the groins and axillæ, and abscesses below the lower jaw and in the neck, in consequence of the greater mobility of the parts in these regions.

Again, an abscess may have destroyed so much connective and vascular tissue before discharging as to leave a cavity the walls of which can not be readily brought into contact for the purpose of union, or in which, if they should approximate, there would be a lack of vessels to furnish reparative material. Here a sinus would follow *in default of power to heal.*

It is apparent, then, from what has been learned from experience, that the formation of a sinus or fistula after an abscess is a consequence, almost invariably, of hindrances which are interposed to the prompt healing of the abscess: namely, of incomplete discharge of its contents, of the presence of mechanical and chemical irritation in the form of constant motion or contact of acrid matters, or of faulty conditions in the approximation of its walls, and of adequate blood-supply for healing.

All these hindrances exist in still greater degree after chronic or cold abscess, without including the lack of constitutional vigor that co-exists with these affections. Thus they explain the generally unsatisfactory treatment of the sinuses following psoas abscess. Here there is some pre-existing cause antedating the formation of the abscess which has prevented its healing, such as diseased bone, or the presence of tubercular matter; and these obstacles to healing must be removed or modified before the sinus can be cured.

The term fistula carries with it, as I have said, the idea of a canal by which some internal cavity has been brought into unnatural communication with the open air, or with another cavity of the body, as a result, not only of unhealed abscess or its progressive ulceration, but also of gangrene, of sloughing of tissue, or of a wound.

I had a case not long ago in which a patient with chronic disease of the bladder began suddenly to pass seeds of fruit and particles of undigested beef in his urine. The explanation of this unusual symptom was

subsequently found in the discovery that an abscess had formed in the walls of the bladder, which, becoming adherent to a neighboring coil of intestine, had discharged itself into the bowel. The constantly changing volume of both viscera prevented healing, and a fistulous communication between bladder and intestine was the result.

Vesico-vaginal fistula, for which our countryman, Marion Sims, first discovered a successful mode of treatment, is most commonly the result of sloughing from prolonged pressure of the child's head against the pubes during labor.

Gangrenous stomatitis of children is liable to perforate the cheek and leave a permanent fistulous opening.

The famous case of gastric fistula in Alexis St. Martin, the Canadian voyageur, by means of which we have been taught so much concerning the physiology of digestion by the experiments of Dr. Beaumont, of the U. S. Army, was the consequence of a gunshot wound of the abdomen. I saw and examined this man at the New York Hospital somewhere about 1850. He was in the hands of a speculator, who proposed to take him to Europe for exhibition. I observed that the somewhat inverted edges of the thickened and puckered skin of the epigastrium at the margin of the fistula leading into the cavity of the stomach, which was about an inch in diameter, were united to the gastric mucous membrane by a narrow line of cicatrix. In this case, therefore, there was simply a *fistulous opening;* hardly a canal.

A similar condition of complete cicatrization often exists in the roof of the mouth after the ravages of tertiary syphilis, and in the majority of cases of vesico-vaginal fistula.

Wounds of the face involving the duct of the parotid gland are liable to be prevented from healing by the escape of saliva externally, and the condition called *salivary fistula* results, in which the patient's clothing

is kept constantly soiled and offensive by the overflow of the parotid secretion.

Nephritic abscess discharging in the loins is liable to leave a fistula, kept up by the constant discharge of pus and urine. In a case of this kind, in a member of our profession in this city, quite a number of renal calculi escaped spontaneously, or were extracted through the fistulous passage, during successive years.

Perineal fistula is a common example of a natural duct or outlet communicating abnormally with the outer air. Here the original cause both of the fistula and also of its failure to heal—obstruction of the urethra by stricture—is illustrated by clinical experience. *When the normal caliber of the urethra is restored by treatment, perineal fistula, as a rule, will heal spontaneously.* This is true of all fistulæ connected with ducts or outlets; every obstruction must be removed, so that the natural passage is rendered as free and direct as it is normally before the fistula can be expected to close. The treatment of fistula lacrymalis furnishes another example.

Fistula may exist from birth, as a consequence of arrest of fetal development. I have seen communication with the theca vertebralis in spina bifida; and once, in a young girl, the permanent fistulous opening of a lymphatic trunk on the side of the neck which distilled a clear fluid. Congenital fistulæ in the median line of the neck result from failure of union of the branchiæ in the embryo; and the urachus sometimes remains patent at the navel.

Art has imitated nature in creating artificial fistulæ, not only as in the gastric, biliary, and other fistulæ made by physiologists in the lower animals to illustrate function by experiment, but also in surgical operations for the relief of disease. As examples I may mention tracheotomy for laryngeal obstruction; artificial anus in the loin or groin for obstruction of the rectum; the establishment of a permanent supra-pubic fistula for

retention of urine from enlarged prostate; and, quite recently, the new operation of gastrostomy. This consists in making a gastric fistula, like that of Alexis St. Martin, in cases of incurable stricture or impassable obstruction of the œsophagus; and this operation has in several instances succeeded in saving life.

Dr. Emmet tells me he has cured cystitis in the female by cutting through the roof of the vagina into the base of the bladder, and thus, by an artificial fistula, placing the cavity of the bladder for a time entirely at rest. When by this measure the catarrhal inflammation of its mucous membrane had got well, the fistulous opening was closed by the usual operation for vesico-vaginal fistula.

It is evident from these examples—which I have introduced in order to render you familiar with the various forms and different causes of these surgical affections—that sinus, or fistula, when not congenital, *is always a consequence of some other lesion*, never taking its origin as such from the onset.

It also necessarily involves the element of chronicity—i. e., the disease is not fairly established until some time has elapsed since the original lesion, whether abscess, wound, or slough, during which time the effort to repair this lesion has proved inefficient and has exhausted itself. It is necessary clearly to conceive this idea of chronicity in order to comprehend the anatomical changes in the tissues which constitute the walls of a sinus or fistula as they appear when examined by the unaided eye or with the microscope. The nature of these morbid changes I will shortly describe.

Meanwhile, I will ask you to observe that the *external orifice* of a sinus, or both orifices of a fistula, are usually smaller than the interior of the canal. Not infrequently, indeed, an external orifice heals over entirely with a superficial filmy cicatrix, to be broken through when enough discharge accumulates behind it. This illustrates again the superior influence of the epi-

dermic cells in stimulating cicatrization; the orifice at the integumental surface shows a much stronger disposition to heal than the walls of the sinus within.

The orifice of a sinus is usually depressed as well as contracted; but it is not a rare exception, however, for the outlet of a fistula to exhibit a sprouting mass of exuberant granulations which mask the opening. This latter appearance is commonly the case with sinuses leading to dead bone. It tells of formative energy still at hand for healing, if there were no hindrance present.

The internal orifice of a fistula in ano can sometimes be distinguished by the finger, in its usual situation just above the sphincter, by the presence of a little soft, pouting mass of granulations, but more frequently by a sensibly depressed circular spot. When situated in the center of a cicatrix, as it often is, the orifice of a fistula presents thin, sharply cut, and gaping edges. There is not infrequently a plurality of fistulous orifices externally, with but one internal opening. In both perineal and anal fistula several openings often exist within a limited area; in old and grave cases, indeed, they cover a larger area; in one case I counted no less than eleven.

These multiple orifices occur in this way: The interior of the sinus or fistula may be irregular in direction as well as in shape; it often deviates and bends suddenly and circuitously, expanding at one point and contracting at another, as it passes through different tissues; the discharge accumulates at an angle or behind a constriction, bursts through the walls of the tract, forming a new abscess and another spontaneous outlet. This process is liable to indefinite repetition, especially where the discharge through the fistula is exposed to contamination by urine or fæces, or where the constitution of the patient is weak and unhealthy.

Fistula may branch by a similar process, and lateral prolongations, when formed, may terminate in blind

expansions or diverticula, which may or may not open externally.

Ordinarily, when an effort to repair the opening left by an abscess, wound, or slough, through hindrance or obstructing causes, has failed, there is, nevertheless, *a prolonged effort at healing kept up in spite of the hindrances*, especially where the patient is vigorous. Hence a probe introduced into a sinus encounters granulations which bleed readily. When a long time has elapsed, the granulations may be less vascular, and the walls of the sinus will be found somewhat more smooth and dense; still later, a sensation may be communicated to the probe, as though it were being passed through an almost cartilaginous tube. In old sinuses of bone their walls may even become eburnated.

It is generally stated concerning old sinuses and fistulæ that they are lined by a membrane—the pyogenic membrane, in fact, of which I have already disputed the existence. In this case it will be found, on careful scrutiny, to consist of a layer of shriveled and degenerated granulations, with some capillaries, and, at some points, a smoothness suggestive of the formation of connective or cicatricial tissue; in short, it is cicatricial tissue arrested in its evolution. In this condition the lining of the sinus may linger indefinitely, awaiting, apparently, an opportunity of renewing its original purpose, and discharging meanwhile a thin, poor quality of pus. In certain cases, where a fistulous tract is very short, absolute cicatrization of its surface-walls does take place, as I have said already, and there is no further secretion of pus from them. The track of a seton or of a suture occasionally heals completely in this way—just as the perforation through the lobe of the ear heals over an ear-ring.

But, ordinarily, the internal surface-walls of a fistula remain raw, red, and velvety. The somewhat condensed connective tissue upon which this membrane-like layer of partially abortive material reposes, of

which it forms the surface and with which it is continuous, has its meshes distended with the germs of leucocytes, and its capillaries still gorged by an increased amount of blood. It constitutes the basis of supply for the anticipated growth of granulation tissue by which the original cavity left by the abscess or slough would have been obliterated *but for the hindrances which put a stop to the healing process.*

The progress of repair, or of "constructive inflammation," as a German writer has lately called this process, having been thus arrested, when a sinus forms, the phenomena by which it is attended gradually subside; but they do not disappear. The pain, heat, and redness, when present (in a cold abscess they are not present—at least externally), diminish in a degree; but the part does not become either entirely cool or absolutely painless. Nor does the turgescence, or swelling, melt away, but it shrinks and becomes more dense. The distended capillaries remain still too large, but the current of blood through them has lost its increased impulse; it is slow, even sluggish. Cell germination after a time is suspended, and the new cells, already formed, develop—some of them irregularly and imperfectly—into connective-tissue cells, which, as they lose their moisture, cause shrinking and increasing density of the resulting mass; others undergo fatty infiltration, and others again degenerate into pus-cells. *This is what the microscope shows us in examining sections of the hard, grizzly material which surrounds a fistula in perinæo,* and which resembles in some of its aspects what we call a sarcomatous tumor. (Cornil and Ranvier, *op. cit.*, p. 453.) The Germans would call it a neoplasm; and so in fact it is.

Thus the tissues around a sinus or fistula, or a group of fistulæ, of any duration, tend to become still more dense and solid as the unnatural tracts become established and acquire age. This series of changes, as I have described them, means simply arrest of progress

in the process of repair by the causes which constitute hindrances to healing—which nature's resources are unable to surmount. Some of these hindrances have been detailed; others have yet to be understood if we are to treat disease successfully, for by removing them the surgeon may aid nature to accomplish a cure.

These changes are significant of interrupted purpose, of forces the action of which has been suspended; but the materials are still at hand for a new reparative effort, if favorable conditions present themselves.

In short, gentlemen, the phenomena I have been describing to you comprise about all that is certainly known of the condition usually called "*chronic inflammation*"; all that is known of the textural changes by which chronic inflammation is characterized, and of their significance. If you examine the thickened tissues in a chronic joint disease, in an eczema of long standing, around an old ulcer, in granular eyelids, or around a sinus or fistula of any duration, you will find identical histological changes, always presenting the same character and meaning. *They constitute evidences of an effort to heal a breach of tissue by development of embryonic substance—which effort has been balked of its purpose and is held in abeyance.*

I have brought before you certain details of the pathology of sinus and fistula, in connection with their causes, because they explain fully the principles of the successful surgical treatment of these troublesome affections. *The general indications for the treatment of sinus and fistula comprise*, first, removal of the cause that is keeping up the disease, and, second, renewal of the arrested effort at healing, with means, of course, for improvement of the general health when required.

The local remedies which have proved successful in the treatment of sinus—from injections of aromatic wine to laying open a sinus with the bistoury and director, and dressing it from the bottom—all are designed to

fulfill the last indication; they act by arousing the parts that form the walls of the sinus from the passive, dormant condition we have just recognized, and by bringing back the active stage of repair—the stage characterized by rapid cell-growth and creamy pus which leads to prompt and permanent healing.

In treatment, the possibility of removing a cause which is keeping up the fistula or sinus, by preventing its healing, is the first question to be decided. Two cases, which I remember with great satisfaction, occurred in officers during the late war, who came to the city disabled by sinuses following gunshot wounds: in one case leading down from the groin to the immediate proximity of the hip joint, in the other extending from the popliteal space to the knee joint from behind. In both cases I succeeded in getting the peculiar leaden mark upon the rough porcelain head of a Nélaton's bullet-probe, enlarged the sinuses—mainly by boring with the finger rather than by using the knife—and thus gained access to the balls and extracted them. In the first case the patient was kept lying on his face for a week, and the sinus healed without any other remedy. The second case recovered almost as promptly, without any serious trouble in the joint.

Pieces of cloth keeping up discharge from the track of a bullet are not so easy to detect and extract. When both ends of the track are open, if one of them has been closed by mechanical pressure, the pus which then collects has been known to float the offending body out at the other end of the fistula.

The sinus below the base of the jaw, known popularly as "tooth-evil," I have always found to get well as soon as the dead tooth, or any necrosed bone which had caused the original abscess, was fairly removed.

When bagging of pus prevents healing, if the skillful use of compresses has failed to bring about consolidation of the opposed surfaces, then a counter-opening at the most dependent point must be made without delay.

Sinuses leading to dead bone, the result of acute necrosis, indicate the necessity of an operation for removal of the sequestrum. A favorite locality for these sinuses is the lower third of the thigh; and the operation always required for the removal of the dead bone in these cases is too often unnecessarily deferred. The idea is held that there is no reason for haste, and that nature may possibly effect a cure. But this idea is false, as the following case will prove: A medical student attending at one of our city schools, not many years since, had one of these sinuses opening at the inside of the thigh at its lower third, the result of acute necrosis in childhood. A sharp spicula, which had become detached from the mass of dead bone, worked its way through the coats of the popliteal artery and gave rise to arterial hæmorrhage from the sinus, which persisted until it was thought necessary, ultimately, to amputate the thigh; and the operation was followed by death. We may learn from the sad issue of this case the danger of neglecting such sinuses.

In another case upon which I operated a traveling sequestrum had invaded the neighborhood of the knee joint; by its removal the joint was happily saved from serious consequences.

I feel it to be a duty, therefore, to advise an early operation in these cases of sinus kept up by dead bone, for nature does not cure them; but judicious surgery, in my experience, has rarely if ever failed.

Tapping a sinus at its source, when this is accessible, and removing its cause, or, if not removable, establishing a direct outlet for the discharge where this can be advantageously done, would prevent burrowing from gravity, and permit the remainder of the sinus to heal.

Of local means to excite reparative action in a fistula, the best are the injection of alcohol in some of its forms, iodine solutions or tincture, the salts of copper, nitrate of silver—the latter sometimes conveniently applied by arming a probe with the fused salt—the galvano-cautery,

the actual cautery. But, where it can be safely done, *the incision of the fistulous tracts throughout their whole extent by means of a director and a curved bistoury, and filling them lightly with lint, so as to secure healing from the bottom, is the surest mode of cure.*

In a sinus of any importance this should be undertaken as a formal and necessary surgical operation, as, for example, in a case in which the usefulness of a hand is involved, from sinuses of the palm, which are not very rare. Here, after careful study of the anatomy of the region, the patient should be etherized and the sinuses explored, so that the parts necessary to be divided may be deliberately determined upon. Then, substituting the director for the probe, slit up the parts upon it thoroughly. If arteries are likely to be involved, previously apply a tourniquet or an Esmarch's bandage, and be prepared to tie the vessels afterward. A hand-splint cut to fit the fingers and applied on the back of the hand will place the part at rest, and prevent any undue contraction during healing. *The object of this operation is to get to the ends of all blind passages and start them a-healing from the bottom, and to permit no stagnation of purulent discharge at any point.* I have been in the habit of applying pure balsam of Peru to these wounds, and then filling them in with picked lint or absorbent cotton. At the end of three days, or thereabout, a large warm poultice should be applied over night to bring away the dressings, or the whole forearm and hand soaked for some hours in a bath of warm carbolized water. As a result, you will probably witness a luxuriant crop of active and healthy granulations.

A prolonged local tepid bath has an excellent effect upon parts in which it is desired to promote granulation. When any poisonous element or unhealthy features are present in an inflamed part, the addition of carbolic acid in small amount—say one part in forty—is

likely to do good. If the acid solution should be used too strong, the peculiar poisonous effects of this drug might possibly result from its absorption.

A minute fistula occasionally forms on the palmar surface of a finger, following a wound, and communicating with the sheath of the flexor tendons. It presents itself as a little blood-colored, spherical tumor, which is nothing more than a mass of granulations. When these are swept away a very minute opening can be detected like the orifice of a tear-duct. Cauterization with a delicate armed probe or wire I have found an efficient remedy.

There is rarely any difficulty about the *diagnosis of a fistula or sinus* unless it arises from the excessive minuteness or temporary healing of its orifice. The latter is a common occurrence. Whenever an unexpected amount of pus or other discharge can be pressed out of an opening disproportionally small, the existence of a sinus is to be suspected; but to determine its exact route and reach its source is not always so easy a task.

In fistula in ano the escape of gas or fecal matter is final evidence of its *completeness*—i. e., that it opens into the cavity of the bowel by its internal orifice. Sometimes the injection of milk into a fistula, while the interior of the rectum is kept in view by means of a speculum, will demonstrate the existence of an internal opening. In obscure cases and in larger sinuses the use of an anæsthetic, and the skillful management of a bent probe, a bullet-probe, or a bougie or catheter, will secure all the information attainable.

In the troublesome fistula which is likely to follow suppuration of a steatomatous tumor it is wiser to remove the cyst; and in fistula leading into the cavity of a bursa the same course is to be pursued, if its walls are dense, although in recent cases, with thin walls, injections of tincture of iodine, or laying open the cavity and dressing it from the bottom, may effect a cure.

Finally, a plastic operation is sometimes required for the cure of a fistula, especially where there has been loss of substance by sloughing; and in parotid fistula opening externally on the cheek, which can only be cured in this way.

In the case of an officer of the army, who had been shot through the mouth and who was left with an opening on the cheek through which the duct of Steno was more or less constantly distilling saliva directly from the parotid, I succeeded in curing his very offensive infirmity by the following operation: In the first place I circumscribed the orifice of the fistula by two elliptical incisions carried completely through the thickness of the cheek, and, detaching the mass thus isolated (except from the duct), passed a thread of siver wire through it, pushed the mass thus transfixed, together with the silver wire, through the hole I had made, into the cavity of the mouth, brought the ends of the wire out between the lips, and fastened them to a tooth. The duct being thus compelled to discharge its saliva into the cavity of the mouth, I proceeded in the next place accurately to close the elliptical wound in the cheek by means of metallic sutures, in which I was skillfully aided by Dr. Emmet. The wound united thoroughly; the silver wire was removed from the end of the duct, and the latter was left to take care of itself, which it did satisfactorily.

CHAPTER XI.

Punctured and penetrating wounds.

After the systematic classification of wounds which I placed before you at the beginning of the course, we proceeded to the study of incised wounds, and, for obvious reasons, we took up the suject of hæmorrhage, and still later the wider topic of *the general mode of healing wounds—the process of repair.* These important subjects were considered in connection with incised wounds, because the latter are more common and familiar to us, occurring as they do in all the cutting operations of surgery. The study of pus followed, necessarily, and afterward, in natural order, that of abscess and its sequelæ—sinus and fistula.

We are now in a position to take up more advantageously the next subject in this classification, namely, *punctured and penetrating wounds.*

I have placed the consideration of *punctured wounds* after abscess, because, if we exclude for the moment those lesions properly designated in works on surgery as *penetrating wounds*, inasmuch as they enter the great cavities and involve internal organs, abscess will remain as the most common, if not the most serious, of all the local complications liable to follow simple punctures.

These latter, properly distinguished as smooth or simple punctures, made by small, sharp, smooth instruments, usually heal kindly and promptly, the piercing of our tissues by such instruments not being, as a rule, seriously resented. We have learned from the Japanese

that the fine, slender needles they employ in the operation of *acupuncture* can be introduced into all parts of the body with safety, even through large nerves and arteries. Hysterical women often swallow needles, which travel harmlessly throughout their bodies, causing only lazy suppuration, exceptionally, as they approach the surface. The needles constantly in use for surgical explorations, for sutures, for subcutaneous injections, in aspiration, as cataract-needles, and as trocars, as a rule make entirely harmless wounds.

When, however, a puncturing instrument is blunt, or rough on its surfaces, so that it bruises or tears the tissues in passing through them, then there is danger of more serious consequences. This difference is so well recognized that it will be found useful to regard *smooth* punctures and *rough* punctures as distinctive classes of wounds; and, in prognosis, the former only, when they are minute, will be found to be devoid of danger.

The dangers to be feared from wounds with larger, smooth weapons, and from rough punctures, arise, primarily, from pus formation, from wound of an internal organ, an artery, or a nerve; and these latter may obviously follow stabs with a knife-blade, or dirk, or the peculiarly American weapons, the bowie-knife and the ice-pick.

A nail entering the sole of the foot, as it tears and crushes through the dense tissues, may readily cause the death of a small shred or fragment of skin or connective substance, or even carry such a little mass before its rough point and deposit it, perhaps, beneath the plantar aponeurosis. This fragment of foreign material must be floated out by pus; and all the symptoms which attend the formation of an acute abscess in a deep and confined situation are likely to follow. It is very much the same as if a drop of a strong solution of nitrate of silver had been deposited here through an injecting-needle, as we do in making an artificial abscess in an animal, in order to study the histological changes

which ensue. The formation of a collection of pus among the numerous vessels and nerves of this region —the sole of the foot—and the difficulty the pus encounters, when formed, in reaching the surface through the dense fibrous layers by which it is walled in, fully explain the great local pain and the corresponding excitement of the whole system which follow.

These phenomena, in ordinary language, are attributed to "inflammation" caused by the injury. This is a popular and perfunctory mode of expressing briefly the succession of phenomena attending the formation of an acute abscess; and I beg you to notice that there is nothing more to justify the use of this word in the present connection than the pain, heat, redness, swelling, and fever which we have heretofore recognized.

The unavoidable frequency of rough punctures of the palms and soles explains naturally the popular dread of wounds of this class, occurring, as they do, most frequently among those who live by the use of their hands. And when we recognize, also, that *tetanus*, or locked-jaw, the most dangerous of all the complications of wounds, seems to happen most frequently after these rough punctures, especially of the feet, it is evident why the surgeon shares the popular opinion. In truth, a bayonet thrust of the thigh is not more dangerous than a rough puncture of the sole. In both cases there is also danger to blood-vessels.

In fact, *lesions of blood-vessels* are of frequent occurrence in punctured wounds, as a few examples will show. When on the subject of hæmorrhage I related the case of a pallid boy brought to the hospital with a puncture of the sole from treading on a nail, in which I was obliged to cut down and tie one of the plantar arteries, from which he had bled repeatedly and profusely. You may remember that the arterial wound was brought into full view, a ligature applied on both sides of it, and the vessel divided. After this the puncture of the sole, having been converted into an incised

wound, healed kindly and safely, by granulation, without further trouble. In this case the pain and suffering of pus formation had culminated, but healing was retarded by the arterial complication, which, without the aid of surgery, might have proved mortal.

I have also mentioned a case of stab of the arm which led to the formation of an enormous diffuse false aneurism, cured, exceptionally, by ligature of the subclavian artery.

My colleague, Professor Wood, cured a false aneurism of the thigh in a boy, following a puncture of the femoral artery by the blade of a pen-knife which he had dropped from his hands, while sitting, and caught by involuntarily approximating his thighs.

In an Italian who was stabbed by a ship-mate through the shoulder from behind, the axilla became distended with blood. It was emptied of coagula through a free incision over the course of the axillary artery, and, when the vessel was exposed, a wound was found in its walls, which was treated by tying the vessel both above and below it, and the patient did well.

These cases illustrate the danger to large arteries from stabs and punctures, the consequences which are likely to follow when they are wounded, and also their most effective treatment. This is what I have already laid down as the only proper treatment of a wounded artery, namely, to attempt to reach the wounded vessel by the most direct route, and to tie it on both sides of the wound. *There is an advantage which is also gained by this course in most of the cases we have now under consideration, namely, that it converts the puncture into an incised wound.*

Lesion of a nervous trunk may be produced by a puncture, or stab, as is shown in the following case: A young man received accidentally a thrust from a small-bladed knife in the back part of his thigh on the outside. It reached and partly divided the sciatic nerve, cutting across those fibers which go to form its peroneal

branch. Paralysis followed—of motion, affecting the muscles, and of sensation, affecting the skin of that portion of the leg and foot supplied by this nerve. More than a year after the accident the patient came under my observation at the surgical clinic of the late Valentine Mott, whose assistant I was at the time. The stab had healed without accident, and he now sought relief for a large indolent ulcer of the sole of the foot, under the heel, which had followed an abrasion caused by projecting pegs in his boot, of the presence of which he had been entirely unconscious. The entire lack of sensibility of the skin of the sole from the cutting off of its nervous supply, which was not as yet repaired, had not only been the occasion of this ulcer, but, as I found afterward, proved to be also a serious impediment to its cure, which was effected with great difficulty.

There is little scope for *diagnosis* in punctured wounds. Probing is to be avoided except when there is good reason to believe that a removable foreign body is within reach. A rapier, in exceptional recorded instances, has passed through the chest without seriously injuring any of the viscera ; and the same is true of the abdomen. Everything should be learned in these cases as to the depth and direction of the penetration by carefully canvassing the circumstances attending the receipt of the wound, and attentively watching for symptoms of injury to internal organs. *Gentle pressure applied over the seat of the injury, to promote consolidation of the walls, is the principal treatment indicated at first in most punctured wounds.* Prolonged immersion in a local warm bath tends to avert more serious consequences when, as in a puncture of the palm, pain may be severe and persistent. If heat and tension come on and increase, these symptoms show that the formation of pus is threatened, and the treatment should be that of an acute abscess. As soon as suppuration can be regarded as a certainty the knife should be used, laying the track of the puncture freely

open, so as to convert it into an incised wound, which is an additional advantage.

I shall transfer the further consideration of penetrating wounds to the heads of wounds of the chest and wounds of the abdomen.

CHAPTER XII.

Tetanus.

In connection with punctured wounds we may profitably take up the subject of *tetanus*, or *locked-jaw*, one of the occasional obstacles to the successful treatment of all wounds, although this unwelcome disease shows itself most frequently in practice as a complication of punctures of the hands or feet.

Tetanus, although a common complication of wounds in certain moist, tropical climates near the sea, is sufficiently rare in its occurrence in our latitude to take the attendant, in most cases, by surprise. At a distance from the sea-board the busiest practitioner, unless connected with a large hospital, is not likely to encounter more than two or three cases in a life-time. There are certain localities in which an exaggerated tendency to the disease prevails habitually. We have such localities in our immediate neighborhood, on Long Island, where it is asserted by a resident physician of large experience* that locked-jaw occurs once, at least, in every two hundred cases of wound, whereas, he adds, in New York city it is met with only once in thirty thousand cases. The most curious feature connected with this exceptional tendency to tetanus in certain places is that in other localities but a few miles distant the disease has never been known to arise, from any cause. So says Dr. Carpenter; and he adds: "The Hamptons, where it is very frequent, are but three miles from Montauk, where

* B. D. Carpenter, M. D., of Suffolk County, Long Island, in "Trans. Med. Soc. State of New York," 1866, p. 186.

no case has ever been known ; again, at Riverhead it is frequent ; five miles away, at Wading River, no case has ever been recorded."

Tetanus certainly occurs most frequently in low sea-coast situations, and is favored by hot and moist weather. The English get a large share of their experience of the disease from their tropical colonies. Sir Gilbert Blane, an English naval surgeon, reports twenty cases of locked-jaw in eight hundred and ten wounded in a sea-fight in the West Indies in 1872; while in northern Europe, Stromeyer tells us, there was only one death in three hundred and fifty of the wounded in the war in Schleswig-Holstein. The French rely greatly upon the authority of Larrey, who found tetanus very common in Egypt. In our semi-tropical climate, especially in the vicinity of the sea-coast, the disease is less uncommon than in Europe.

The outbreak of tetanus in an individual is very likely to have been provoked by sudden chilling of the body, either by change of weather, exposure to cool winds, or draughts of air. I once had a case, in the adjoining hospital, which was caused evidently by sleeping near an open window.

Tetanus sometimes occurs spontaneously, but far more frequently and in more fatal form as a complication of wounds ; and it is generally supposed to be more readily excited by wounds in which nervous trunks are involved. Billroth had a case of compound comminuted fracture of the lower end of the radius in which the median nerve was torn half across. Locked-jaw suddenly set in on the third day, and caused death in eighteen hours.

Beyond what I have said, we know little or nothing of the causes of this cruel disease ; and as little, perhaps, of its real nature, and of its morbid anatomy. It is essentially a neurosis, beyond a doubt, and its central seat is in the spinal marrow ; and yet both the temperature of the body and the pulse usually reach a high

figure. In my judgment, the best speculative opinions as to the nature of the disease are, that it consists in an enormous exaggeration of reflex excitability in the spinal nervous centers, and that this takes its origin in a peripheral lesion of nervous tissue ; or, that it is due to some subtile alteration of the blood, analogous to that produced in poisoning by strychnia. These opinions, as you will observe, cover the two cardinal sources, to one of which every form of constitutional disturbance is, at the present day, habitually attributed, namely, "nervous sympathy" and "blood-poisoning."

The chief phenomenon by which tetanus is manifested is tonic muscular spasm, or cramp, severely painful, persistent, invading different groups of voluntary muscles in succession, and accompanied by paroxysms of more painful and more or less general intensified cramps, at intervals which are shorter in proportion to the severity of the case. These paroxysms last from a few seconds to several minutes. The disease causes death, as a rule, within a week, in a proportion of nine cases out of ten attacked.

The earliest symptom of tetanus is a sensation of stiffness around the back of the neck and in the muscles of the jaws. This the patient generally speaks of as "rheumatism"; and the physician, unless he is forewarned, will be likely, at first, to share his mistake, and overlook its more serious meaning. At the next visit there will be recognizable difficulty in opening the mouth, and probably a complaint of severe pain at the pit of the stomach, perhaps rigidity of the recti muscles of the abdomen, which gives this region a peculiar feeling of hardness to the touch ; the belly feels "as hard as a board." After this the tetanic rigidity is developed in the great extensor muscles of the spine ; and soon there is a distinct *paroxysmal outbreak of general cramps*, attended by intolerable pain. This paroxysm of general spasm recurs at intervals varying from a few minutes to several hours, according to the rapidity of

progress of the symptoms and the possible palliative influence of remedies.

Paroxysms are liable to be provoked by loud noises, or any exciting and disturbing influences. As the disease advances the rigid condition of the muscles becomes more general, and finally the diaphragm and the muscles of respiration are all involved; and then, during a paroxysm, the breathing is suspended, and, if the stress of the spasm holds on long enough, death may now take place at any moment by actual suffocation.

In a fully developed case of tetanus the muscles of the face are rigid and more or less contracted; the eyes are half-closed, the corners of the mouth drawn up and the lips slightly parted—showing the teeth; and this constitutes the tetanic physiognomy—the "sardonic" expression described by authors. Now, when a paroxysm comes on, the whole trunk may be curved violently forward by the spasmodic contraction of the powerful spinal muscles, so that the body may be for the time supported only on the heels, elbows, and back of the head. This is called *opisthotonus*. Less often the *flexor* muscles of the trunk bear the brunt of the spasm, and the body is curved forward. This is *emprosthotonus*. Still more rarely the trunk is curved to one side or the other.

The body is often bathed in perspiration, through the stress of suffering. This feature of sweating has been regarded as an eliminatory effort. There is general exalted sensibility, especially in regard to cold draughts of air.

With the persistence of this group of symptoms the heart's action will be found to be steadily losing force and the pulse becoming more frequent. There is little desire for food; more for drink. The bowels are costive and the urine scanty, and sometimes voided with difficulty. There is a strong desire for relief from pain, and for sleep. The functions of the brain are uninterrupted by the disease. I have never seen delirium, un-

less provoked by narcotics. The intelligence is clear to the last. Death occurs, either during a paroxysm, by strangulation, or, later, by gradual exhaustion from want of rest, continued pain, and failure of nutrition.

The first-mentioned mode of death is typical in acute tetanus. I once witnessed it in a young gentleman who had shattered his hand by a fowling-piece, a patient of my former colleague, Professor Metcalfe, and we made a strong effort to save him by chloroform, which at the time had not been long discovered. We were with the patient, together or alternately, for nearly forty hours, keeping him moderately anæsthetized and sleeping, and applying the vapor more freely as he showed symptoms of awaking with a paroxysm. The paroxysms were distinctly decreased in frequency and greatly controlled by the influence of the drug. But, after a longer interval of sleep than usual, he finally sprang up suddenly in a stronger seizure than ever before, choking; he could not get his breath, and strove at first violently to clutch at his throat. The chloroform vapor, which was instantly applied, failed for the first time to relax the spasm—for none of it could enter the lungs. The cramp became general, and very intense; meanwhile, the color of the face grew steadily deeper and deeper in its livid tint, but there was no sign of relaxation, and, in about a hundred seconds, as nearly as I could estimate the passage of the time, the poor fellow fell back upon the pillow, dead. It was as though an invisible giant had seized him by the throat and choked him deliberately to death.

An analysis of the *symptoms* of the disease which I have enumerated will help us but little except to elucidate the mode of death. We may notice that the tetanic rigidity invades certain groups of muscles in regular order of succession, the motor branch of the fifth pair taking its part with the spinal nerves in conveying a morbidly intensified stimulus to muscular

force from the over-excited spinal center. The first muscles affected are those of the nucha, and the masseters; and the last, those of the eyeballs, of the fingers, and of respiration.

I doubt if spasm is possible in the unstriped muscle in the walls of the hollow viscera, although the costiveness of tetanus is generally ascribed to this as a cause. As far as I can learn, permanent spasm can only exist in voluntary muscle.

When tetanic spasm has fairly set in it *never entirely relaxes* until the disease ends in death or recovery. After the paroxysms of intense exacerbation there is partial relaxation and relief from the extreme distress; but never entire relaxation, as in health. *This is a fact of value for the diagnosis of true tetanus.*

There are said to be exceptional cases of tetanus, in which there is no fever. Follin, a high surgical authority in France, speaks of it as an apyretic disease. The frequency of pulse which I have invariably observed, whatever its immediate cause, is certainly the *best guide as to the rate of failure in strength.* The high temperature which is said by Billroth to have been observed to increase for a time even after death, lends color to the speculative opinion as to the existence of a poisonous change in the blood.

As to *post-mortem appearances*, proliferative and degenerative changes have been observed in the substance of the cord by Rokitansky and by Lockhart; congestion in the sheaths of the spinal nerves; bloody effusion and actual rupture in the substance of voluntary muscles; and, in rare instances, fracture of bones. But it is difficult to prove that the changes in nerve substance and neurilemma may not have been, like the lesions of muscle and bone, consequences, and not causes, of the disease. Billroth and others have examined carefully for lesions of nerve substance in the cord, and failed to find them.

As to *diagnosis*, it is important to know that there are "*tetanoid*" *muscular spasms* of the limbs from wounds which are not true tetanus. They are always accompanied by *pain of the wound*, which is exceptional in tetanus; these tetanoid spasms are not preceded by trismus, and they also present intermissions of entire relaxation, which never occur in the true disease. *Spinal meningitis*, in which spasms and rigidity of the limbs occur, is a disease of marked features, in which frank strong fever exists from the first. It never presents the symptom of trismus, although there may be stiffness of the neck and difficulty in swallowing. This last symptom, difficulty in swallowing, has led some to confound tetanus with *hydrophobia*, because there is actual difficulty in using the jaws in tetanus, and a certain dislike to attempt swallowing, through fear of bringing on a paroxysm. But in hydrophobia the spasmodic paroxysms are convulsive, attended by irregular intermittent movements followed by entire relaxation—in short, they are *clonic* spasms; whereas those of tetanus are steady, continuous, *tonic* cramps, which subside in their intensity after a paroxysm, but never relax entirely. This latter feature will also serve to distinguish tetanus from *strychnia poisoning*, in which there is entire relaxation and quiescence between the paroxysms. *Hysteria* imitates tetanus very closely; and when the latter disease presents itself in a woman, which is comparatively a rare occurrence, its symptoms should be scrutinized with care, and also with suspicion. In the case of a young woman who had undergone an operation for necrosis of the tibia, I was for several days doubtful as to the issue, so accurately were the symptoms of tetanus reproduced. After complete relaxation, and some hours of quiet sleep, the paroxysms returned in this case, and were repeated with increased severity for several days. Now, relapse after complete relaxation does sometimes occur in true tetanus during convalescence, and may even prove fatal. A case is on

16

record of a boy who was regarded as entirely convalescent, so that he was allowed to go to the breakfast-table, where he was seized while eating a piece of beef-steak, and died in the paroxysm. Of course, in this case, the mouthful of beef might have been alone the cause of suffocation. In the question of *hysteria*, the fact of the sex, the moral and physical qualities of the patient, and the discoveries which are sure to be made by suspicious watchfulness, will generally furnish sufficient evidence for diagnosis.

In *prognosis*, the best ground for hope lies in finding some reason to doubt the diagnosis, for, when true tetanus is present in its acute form, there are few diseases in which the chances for life are more desperate. In 363 cases gathered from the records of our late war,* 336 died, leaving a percentage of recoveries of only 7·5, or one case of recovery in fourteen. This I believe to be a fair statistical record of the mortality in acute traumatic tetanus. In tetanus that shows a tendency to assume a *chronic* type, and in the *spontaneous* or *idiopathic* form of the disease, the chances of life are far better. I know of no reliable statistics, but I should judge, from the opinions of apparently competent observers, that a large majority of these latter get well. If, therefore, in a given case of tetanus, the disease advances slowly, the paroxysms coming on with long intervals, and especially if the pulse does not become frequent, and the temperature does not run up, and if the patient can take food, and if he can sleep, these may all be regarded as favorable indications.

But it is to be remembered that the disease is treacherous, and often after a mild beginning it may grow rapidly worse on the third or fourth day, and terminate fatally within the week. This is the limit of life in a large majority of fatal cases. The disease has caused death in twenty-four hours, and not infrequently on the third, fourth, or fifth day. Fewer deaths, in pro-

* S. G. O. Circular, No. 65.

portion to surviving cases, take place during the second week; and, if the patient reaches the third week, his chances improve rapidly, but there is still great danger, and a case of acute tetanus that survives always convalesces very slowly, and requires careful oversight for a long time.

The period after a wound at which tetanus may declare itself is very uncertain. There is no time after which he can be considered absolutely free from danger; the disease has occurred during healthy granulation, and on the eve of cicatrization; and it has even appeared after cicatrization. There is some evidence that cases occurring at a late period after the reception of a wound are more likely to be mild.

The treatment of tetanus is certainly as unsatisfactory as its ætiology, and yet there is always room for hope that the skillful management of a case may have influence in saving life. There is better ground for hope from wise and careful oversight than from the virtue of any of the reputed specific remedies. Intelligent and faithful nursing is of especial importance. Preventive measures seem to me to deserve more attention than they usually receive. The undoubted influence of chilling, not only of the body but of the wounded part, in provoking an invasion of the disease, can be often prevented by foresight. I have hoped much from the general employment of antiseptic dressings in the treatment of wounds, for they have at least an influence in preserving an even temperature in the wounded part; and carbolic acid possesses a certain degree of benumbing power. The mode of employing cotton wool liberally in dressing, after the plan of Alphonse Guérin, in addition to its antiseptic influence, is especially useful in keeping up an even temperature about a wound. Without having positive evidence to offer, I have formed a favorable opinion of this mode of dressing as a preventive of traumatic tetanus. The protection it affords from the effects of motion and mechanical sources of

disturbance is very positive. The failure of prompt amputation to cut short the disease, or even to influence it favorably, has certainly thrown discredit upon the theory of reflex irritation.

As is usually the case in an intractable disease, its reputed remedies are very numerous. Tradition treasures up the means of cure under which the small proportion of recoveries has taken place, and for the most part attributes exaggerated virtues to them. But there are really no remedies for the disease which have proved worthy of the name.

The best plan of treatment you can adopt at the present time is to secure for your patient, *in the first place*, absolute quiet, a trained nurse, and pure warm air, with protection from exposure to sudden changes of temperature. *In the second place*, a systematic administration of concentrated liquid nourishment, of which good milk is the type. The mastication of solid food, even if possible, is liable to provoke spasm and endanger biting of the tongue and suffocation by choking. The nourishment may require to be injected by a syringe, and, when the teeth are in full number, the tube can be inserted behind the last molar ; the feeding requires gentleness, judgment, and perseverance. It is to be borne in mind that the fight for life may be a long one ; and that many of the deaths after the first week depend, in a large degree, upon failing strength from insufficient nutrition. *In the third place*, alcoholic stimulus, in the most suitable form—the best combination is with milk. It should be given judiciously, but rather liberally, and increased steadily without regard to quantity—only effect. *In the fourth place*, opium, preferably in subcutaneous injections of morphine, in sufficient doses to keep the patient drowsy and ready to sleep, and to control pain as far as possible, regarding no rule as to quantity in securing its effects, except the influence of the drug upon the pupils and the respiration.

These rules constitute the best basis for treatment. Any specific remedy may be employed in addition, provided that it be administered carefully and systematically, without interfering with the above plan, or depressing the powers of life. Among these, curare and the calabar bean are at present most in vogue ; and the latter has still some warm advocates. To replace opium, or aid its action, the bromide of potassium and the hydrate of chloral, in full doses, have certainly given satisfaction in commanding longer and sounder sleep. For the bowels, which generally require aid, large, warm injections containing a dose of spirits of turpentine, or tincture or milk of assafœtida, are useful. When there is pain or difficulty in voiding urine, heat applied over the hypogastrium is the best palliative. The catheter may be required. A local authority, already quoted (Dr. Carpenter, of Long Island), praises highly the continued application of pounded ice to the head and spine. Four successful cases are detailed, and an aggregate success claimed of twenty-six out of thirty-seven cases. This record, it may be presumed, includes spontaneous or idiopathic cases of the disease which, I am told, are not uncommon on Long Island, and quite a large proportion of them get well spontaneously.

CHAPTER XIII.

Contusions and contused wounds.

Contusions and contused wounds constitute the next subject in order in our classifications of wounds and injuries. *Simple contusions, or bruises*, form a distinctly marked class of surgical injuries, and, although they are subcutaneous lesions and enjoy the advantages of repair as such, they are properly classed with contused *wounds* in consequence of the similarity of their causes. Both are produced by the forcible contact of more or less rounded, blunt, hard bodies, with the soft living tissues, applied always from without, as, for example, a blow from a closed fist, from a policeman's club, the contact of the body with hard surfaces, as in falling, etc. Not infrequently these causes are aided in their injurious effects by the unyielding resistance of bony surfaces and prominences beneath the skin. The result varies in extent and severity according to the magnitude of the impinging body and the degree of force employed. The immediate *symptoms* produced by simple contusion are pain, dull and aching in character; nervous tingling or numbness; perhaps local paralysis if a nervous trunk be involved; possibly general shock or collapse, or insensibility from stunning. But the most characteristic symptom of an ordinary contusion follows, after a short interval, in the shape of what is known as *ecchymosis*, or effusion of blood beneath the skin from crushed and torn blood-vessels.

The bruising force may be severe enough to kill the external integument, and perhaps the parts immediately

beneath it, if a bone lie near at hand against which they may be crushed. When the slough or eschar thus produced has been cast off, we have to deal with an open wound—technically described as a "*wound following contusion.*"

Again, the injuring force, besides bruising, may at the same moment break or crush through the integuments, in which case there is at once an open wound; and this is called, in surgical language, *a contused wound.*

These several lesions have each its peculiar features. *At present we shall confine ourselves to simple contusions*, which heal, for the most part, beneath an unbroken skin, away from contact with the air.

Contusion, or bruise, may present *different degrees of severity:* First, only the smaller blood-vessels of the skin, subcutaneous fascia, or superficial muscle, together with the substance of these tissues, may be crushed or lacerated. Second, larger surface veins may be torn across, and the superficial fascia may be torn away from the parts beneath; or arteries of some size may be involved. Here the effusion of blood is greater, and may form a mass of coagulum; there may possibly be arterial pulsation, communicated to the mass by several small arteries; or, from injury to a larger trunk, even a false aneurism may result. Third, a whole limb may be severely crushed—possibly converted into a pulpified mass, as when the wheel of a railroad car has passed over a leg, or a spent cannon-ball has disorganized a part of the body by its contact. It is evident that *crushing* is only another form, a more intense phase, of contusion. Such injuries as follow the caving in of a bank of earth form a common class of hospital cases; they are often accompanied by serious internal injuries; or the forcible compression of the shoulders or thorax between the side of a stall and the body of a fractious horse, which I have known to cause simultaneous fracture of both clavicles and several ribs; or the crushing

of the abdomen between the buffers of railroad cars, causing laceration of the liver, or rupture of some of the hollow viscera. All these are, strictly, intensified contusions.

It is evident, therefore, that the class of simple contusions covers a wide range of injuries, some of which are very trifling, and others again are necessarily mortal.

Medical jurisprudence emphasizes especially the necessity of familiarity with surface ecchymoses as evidence of unlawful violence. It is important for you to know how trivial a pressure will give rise to a black and blue spot upon the arm of a fleshy woman, for example —simply because the subcutaneous capillaries, already on the stretch by reason of the fat, give way more readily under slight pressure. It is necessary to know, also, that extensive ecchymoses make their appearance spontaneously in persons who have scurvy, the alteration of the blood in this disease begetting friability of tissue and easily ruptured capillaries. A simple fracture, produced by direct violence, is in reality the result of a contusion. The humerus may be broken by a blow from a large round stone, as I have witnessed; and here there may be but slight evidence of bruising of the external soft parts at the time, but there is often a quite extensive discoloration in bluish-green and yellow tint of the skin that makes its appearance one, two, or even three weeks later.

This tardy manifestation of *deep ecchymosis* is so characteristic of fracture that its occurrence would lead me to suspect the existence of this lesion, even in the absence of its more ordinary signs. The effused blood, or rather its serum holding coloring matter in solution, travels along the loose connective tissue between the muscles and their aponeurotic sheaths, and, escaping through lacerations in the latter, works its way slowly to the surface, the superficial area of discoloration increasing in proportion to the distance from its source. The hæmatin of the blood, at first dissolved in its se-

rum, takes the form, later, of orange-colored crystals of hæmatoidin, which are almost insoluble; hence the yellow tint after a bruise which is so slow in disappearing. If a bandage has been applied around a bruised limb, the discoloration will be found to be least where the pressure of the folds of the bandage has been greatest, showing the influence of compression in obstructing the passage of the discoloring fluid through the meshes of the connective tissue. Wherever this is most free from fat, as in the eyelids, the bloody fluid will most readily accumulate. The influence of gravity manifestly aids in this result, as is illustrated by the huge size and dark purple color often seen in hæmatocele of the scrotum.

We are all familiar with the rapidity with which a great soft lump will crop out after a blow received upon a vascular part of the body, as upon the scalp; the bloody tumor so common upon the vertex of a newly born infant is the result of a slower bruising process. Sometimes even arterial pulsations may be detected in a bloody tumor following a sharp blow. But, where there has been no deeper injury, neither the size nor the suddenness of the bloody effusion, nor even its pulsation, need excite apprehension; for the blood will very soon coagulate in and about a crushed arterial branch so near the surface and cut off its communication with the rest of the effusion, causing the pulsation to disappear, and the main bulk of the swelling will soon shrink, by absorption of its more liquid portion.

Billroth relates a hospital case of a robust man who broke his tibia about its middle, evidently from direct violence, the fibula giving way, as usual, lower down. In the very considerable swelling which formed immediately at the seat of fracture, the surgeon detected, on the front of the limb, very obvious pulsation, attended by a distinct murmur recognizable by the stethoscope. The leg was put up in simple splints and bandages in such a way that the traumatic aneurism could be watched

from day to day. It soon became evident that the swelling was diminishing, and the pulsation at the same time growing more feeble; and at the end of a fortnight both had disappeared. At the end of the eighth week the man was discharged with a good leg. This case shows the resources of nature in the prompt cure, by coagulation and absorption, of a bloody effusion from contusion, even when arterial branches are involved to an extent sufficient to occasion pulsation. The only remedies employed were rest and light pressure. It should teach us to guard against unnecessary alarm. and also to abstain from officious interference.

There is an interesting feature about these *bloody swellings of the scalp* from blows and bruising that is worthy of note: they present a sharp abruptness about their edges at the limit of the central soft part which gives to the fingers almost precisely the feeling of a circular depressed fracture of the skull; and, as such an accident as this might possibly follow a blow upon the head, it is necessary to be prepared with a prompt diagnosis. This is accomplished by making firm enough pressure over the soft central swelling to feel the *unbroken bone beneath* in its proper place. The sharp edges are caused by the coagulation of the blood in the meshes of the subcutaneous connective tissue immediately surrounding the greater bulk of the central effusion.

On the other hand, although it is rarely present, do not take it for granted that there is no fracture when you encounter a bloody tumor of the scalp. There was a man once taken to the Tombs staggering drunk, as was supposed, with a soft lump upon his head, which was assumed, without any examination, to be one of the bloody tumors I have described. As the symptoms attributed to intoxication still persisted at the end of several days, the man was sent to the hospital; but on the way thither he died. On examination, a perfectly circular, depressed fracture was found in one of the

parietal bones, fitting exactly the bulge of the most common form of that dangerous weapon, a slung-shot. Beneath the fracture were found inflammatory changes of the membranes of the brain, and softened brain substance. The poor fellow had recovered from his first symptoms of concussion and compression, through the brain accommodating itself to the pressure, to die with *traumatic cerebritis*—which might possibly have been prevented by timely elevation of the depressed bone by the trephine.

In connection with the *diagnosis* of contusion and fracture, I will mention also that, in examination of a recently bruised part with the fingers, the practiced touch will sometimes recognize a sensation of delicate crackling, due to the breaking up of the little masses of fibrin which have just coagulated in the meshes of the connective tissue. This is to be distinguished from a more curious phenomenon sometimes noticed in large contusions accompanied by extravasation, namely, a fine crepitation, which is caused by the momentary extrication of gas in the interior of the contused tissues. This latter symptom has little significance, and disappears in a few days, or even in a few hours; it is entirely different from the emphysematous crackling of more common occurrence that arises from the extrication of gas from severely injured parts which have fallen into putrefaction. While examining a bad sprain of the ankle, attended as usual by extravasation around the malleoli, and keeping in view the possibility of fracture, I have not infrequently had my attention arrested by the crackling of recently deposited fibrin, even within an hour or two after the accident, which I can readily conceive might be mistaken for the crepitus of fracture.

In cases of sprain severe enough to cause effusion of blood around the malleoli, it is wiser to etherize the patient, and thus secure a thoroughly satisfactory examination; for fracture in this locality, through difficulty of getting true crepitus in consequence of the binding

down of the lower fragment by its ligamentous attachments, is not always easy to detect.

It is as well now to inquire what becomes of blood poured out among the tissues as a consequence of contusion. As a rule, it is promptly absorbed by the lymphatics, and disappears. In the exceptional cases in which prompt absorption fails to take place, an abscess may result, preceded by the usual symptoms ; or by a slower process, and without inflammation, a cyst may possibly form. More rarely, the blood-clot may become organized, and the neoplasm may remain as an overgrowth.

A good many years ago, on commencing a tour of duty in the adjoining hospital, I found in the ulcer ward a man past middle age with an enormous contusion on the front of the right thigh. A mass of plastering from the ceiling of the ward had fallen upon him as he lay upon his back, a month before, with an ulcer of the leg. The swelling on the front of his thigh was very large, hot, and prominent, and the skin over it was yellow and dusky red. Suppuration of an old extravasation from contusion was evidently imminent. I learned that the man's habits were bad, and that he had not kept quietly in bed since his injury, as ordered. The local heat and tension in the tumor increased ; he had rigors, and his temperature ran up. When ulceration had thus become inevitable, I felt justified in making a free opening, through which I turned out nearly a quart of grumous blood-clot mixed with pus. There was no absolute putridity in this ill-looking mixture, but I nevertheless washed out the cavity very freely with warm water. The patient did well for a number of days, when suddenly quite free hæmorrhage took place, evidently arterial, from some point at the bottom of the huge, irregular cavity, and it was necessary to apply the tourniquet. I had the patient put upon the operating table, and, with a good light, endeavored to find and secure the vessel, which gave forth blood very

freely whenever the tourniquet was relaxed. But I failed in my efforts to secure it; the softish material by which the walls of the cavity were lined (inflammatory neoplasm, or, in other words, granulation tissue) gave way on repeated trials with the tenaculum, and the ligature would not hold. Every additional trial and failure seemed to multiply the number of the bleeding points. I was compelled, therefore, as the best chance for securing the patient's safety, to place a ligature on the femoral artery. This happily arrested the bleeding; and in the end he was so fortunate as to get well without further interruption.

A gentleman was sent to me some years ago with what was supposed to be an enlargement of the left testis. It was a tumor in which the testis could not be distinguished—smooth, round, and of soft, solid, fleshy consistence. He had taken several opinions, and had arrived firmly at the conviction that the growth was at least of a suspicious character, and he was anxious to get rid of it. The enlargement was of some years' duration; it had originated in a bruise. I was uncertain as to its exact nature, and proposed an exploratory operation in which the tumor was to be cut into and carefully examined before the spermatic cord was laid bare and divided as in castration. The result was that I found a perfectly healthy testicle enveloped by a tunica vaginalis at least an inch in thickness, the additional material being organized blood-clot, evidently the result of an old hæmatocele. This I removed very thoroughly, and the patient made a good recovery, having preserved a healthy testicle.

I was prepared for this result, for I had assisted one of my colleagues at the New York Hospital in a similar case, some years before, in which the tumor was much larger.

Contusion in its extremest degree terminates necessarily in death of the injured part, or gangrene. This is exemplified where the wheel of a railroad car has

passed over a leg. Here contusion is carried to absolute crushing. After such an accident we find the external skin often unbroken, while the parts within are crushed to a pulp. It is a source of surprise in such a case that the limb retains its shape, and that there is in most cases absolutely nothing on its surface save a brownish, livid discoloration marking the track of the wheel. The patient suffers little pain, for the nerves of the part are killed outright by the sudden and overwhelming force ; and his general condition is characterized by the peculiar half-stupor or apathy belonging to the state of shock which accompanies great surgical injuries.

In such a case of extreme contusion or crushing as this, the proper resource is to remove the limb by amputation as soon as the condition of shock has been sufficiently recovered from. If this be not done the limb will fall into gangrene, chemical changes will take place, the liquefying dead tissues will be carried into the blood in overwhelming quantity, and the patient will die, in most cases, from collapse and putrid poisoning, or, as it is also called, *acute septicæmia.*

Animals may recover from such crushing of a whole limb, but in man it is properly regarded as a necessarily mortal injury, for which prompt amputation offers the only chance of recovery.

As if to prove this rule, I will mention a case in which an exceptional degree of vitality was manifested —such a case as occasionally sets all our rules of prognostics at defiance, and serves to explain why an old surgeon is generally more cautious in his opinions and prognoses than a young one. It occurred some years ago at the New York Hospital. A middle-aged man named Reid, always a hard drinker, was found one Saturday night on the railroad track near Poughkeepsie, dead drunk, with both legs crushed. This double injury was regarded as necessarily mortal by all who saw him. Nevertheless, on the following Monday he

was still alive, and well enough to be forwarded to the city, where I found him at my regular hour of visiting the hospital. His condition was sufficiently good to justify the removal at once of one of the legs below the knee. He bore this so well that I felt warranted in removing the other the day but one after. This man got well without any bad symptoms, and in the usual time. I should be sorry that the mention of this case, which is simply an example of unusual tenacity of life, should be regarded as warranting delay in resorting to amputation after railroad crushing of a limb. It should rather encourage us in adopting so desperate a resource in order to save life. The rule is that the sooner the operation is done, after the extreme degree of contusion of a limb has been suffered, the better the chances for life.

Finally, there is still another mode in which effused blood is liable to be disposed of after a contusion, and that is *by suppuration.* Where the original injury has been very severe, and the contused parts have not been kept at rest, or have been exposed to repeated mechanical violence, all the symptoms of abscess formation may make their appearance, and the effused blood may be eliminated as though it were a foreign body.

I have a word to say concerning *contusion of nerve substance.* The temporary suspension of function of the brain, or of the spinal cord, described by the terms *concussion* and *commotion*, belong to the class of injuries we are now considering.

The stunning that follows a severe blow is an effect of *contusion* of the cerebral mass, and the same is true of falls or blows producing temporary paralysis of the limbs by their effect upon the spinal cord, whether the force be transmitted to the nervous centers directly, as by a blow upon the head, or indirectly by a fall upon the feet or elsewhere.

The painful sensation of exhaustion caused by a blow upon the pit of the stomach, which is said even to

have caused death—of which I am doubtful; the severe aching pain, numbness, and tingling, extending to the little finger, which follow a blow upon the ulnar nerve at the elbow; and the paralysis of the deltoid muscle from a fall or blow upon the shoulder, which stretches the circumflex nerve where it half encircles the neck of the humerus—are all examples of contusion affecting nerve substance.

Unless complicated by more serious lesion of other parts, these nerve contusions are in most cases, sooner or later, recovered from. The most noticeable exceptions which I have encountered are the prolonged effects of the tremendous violence inflicted by railroad accidents and collisions upon the nervous centers; and the fatty atrophy and permanent loss of function of the deltoid muscle after a fall upon the shoulder, which is explained by the fact that its nerve supply is derived solely from the bruised circumflex, and that the muscle falls into atrophy before the nerve recovers its function of conduction. In treating this last-mentioned injury I would suggest that the deltoid should be constantly subjected to exercise by means of the galvanic current, in order to prevent atrophy from non-use, so that when the injured nerve resumes its functions the muscle may be ready to respond. I have seen good results from this remedy.

Of the severe contusion of nerve substance from railroad accidents I shall speak hereafter.

As in violent sprain of ligaments and tendons near joints (a form of injury very nearly allied to contusion), a bruise is sometimes followed by *excessive pain*, of the character of a paroxysm of neuralgia. For this the best local remedy is the application of *heat in as great a degree as can be borne*, and preferably by fomentations with hot salt water.

The disappearance by absorption of blood effused in contusion is, in some cases, so exceedingly slow that the practitioner might seriously ask himself if he should

not be justified in treating the collection, when small and clearly defined, as an *encysted tumor*—which in some sense it is—and removing it. Painting with iodine, and blisters, are not always efficacious; and stimulating remedies might provoke suppuration.

Under these circumstances, pressure is probably one of the best remedies to try—by means of a bandage and compressed sponge, or by pressure carried so far even as to burst the false cyst and distribute its contents in the surrounding connective tissue, where it would be likely to undergo absorption—the treatment applied to ganglia upon the sheaths of tendons.

Contusions of joints are often seen in persons brought to the hospital who have been hurt in blasting rocks, in railroad accidents, or by machinery. They are liable to complication, in severe cases, by laceration of the synovial membrane and effusion of blood into the cavity of the joint. Fracture near the joint, or into it, is not very rare. A boy was thrown from his pony, which stepped upon the lad's shoulder as he lay upon the ground, and the result was a contusion of the shoulder-joint, with distinct separation of the head of the humerus at the line of junction of the epiphysis with the shaft. He got good union in little more than two weeks, with a pad in the axilla and an outside splint molded to the shoulder and arm.

Extravasation of blood outside of the injured joint should not be mistaken for hæmorrhage into its cavity; and yet they might co-exist. The use of the aspirator would determine the question.

The treatment required for a contused joint is a wire splint and a spirit lotion, in mild cases, until heat and swelling have subsided, and then moderate pressure by bandage, with judicious attempts at passive motion. In case of excessive and persistent heat and tension, the joint should be covered with leeches to avert exudation or suppuration. If the excitement be of lower grade and slow in subsiding, counter-irritation by blisters is

17

advisable; but, above all, absolute rest for a time. Jarjavay, of Paris, in distention of a joint by effused blood, reports successful results after evacuating it by means of a valvular opening. This might be safely done with antiseptic precautions. In excessive distention by serum I should prefer the aspirator.

From what I have said, it may be inferred that the main features in the *treatment* of contusions in general are to secure rest and protection for the injured part, and to rely with confidence upon the efforts of nature for repair of subcutaneous lesions, when moderate in degree, and for absorption of effused blood. With the additional remedies already suggested for special cases, I think that this expectant plan of treatment can not be too honestly carried out. There is, in fact, danger in officiousness.

The early application of cold, or moderate pressure, as by means of crushed ice in a bladder, tends to limit the effusion of blood. Certain lotions have a reputation for promoting absorption—e. g., muriate of ammonia dissolved in camphor-water, an ounce to the pint, with the addition of a little spirit; dilute tincture of arnica, or witch-hazel.

The application of leeches to a recent bloody tumor is unwise, especially when seated upon the head of a child. They do not draw out the effused blood, as is popularly believed, and they do cause pain, and sometimes unnecessary irritation, and loss of blood. As to "prevention of inflammation"—the popular ground for apprehension—absolute rest in a large majority of cases is a more efficient measure than loss of blood. On the other hand, when employed exceptionally, as I have advised, in the case of a contused joint, to prevent disorganization of parts from excessive action, leeches should be applied most liberally, and in successive relays. I have seen great benefit from their use under these circumstances; but there must be no limit as to numbers. Here they prevent con-

gestion from afflux, and lessen the tendency to exudation.

There is an important class of injuries, already mentioned, which may be properly considered in connection with the foregoing—*sprains* of the soft parts around the joints. They resemble contusions, not only in the frequent co-existence of ecchymosis from tearing of surface blood-vessels, but because they also, for the most part, undergo repair beneath the surface, away from the contact of the external air.

A sprain results from violent wrenching of a joint, in which its normal limits of motion are forcibly surpassed. The most common seat of sprain is the ankle-joint, and it is often produced in jumping from a carriage or a railroad car in motion, where the weight and the enormous leverage of the body are brought to bear upon this joint suddenly, and with great force, as the foot touches the ground. Death rarely follows this injury when moderate in degree, unless it is complicated with others of more gravity; and therefore post-mortem examinations afford us but scant evidence as to the exact lesions which are produced in sprains.

Experiments upon the dead body by Bonnet, of Lyons, have added some facts to our knowledge. It has thus been shown that the stress of the injury, as we should presuppose, falls upon the ligaments which hold the joint surfaces in their proper relations. These are often partially, but rarely completely, ruptured. The tendons around a forcibly twisted joint are put upon the stretch, but not often torn across, although their sheaths are frequently dragged upon and lacerated. Muscle (e. g., the gastrocnemius near the junction with its tendon) has been known to give way; connective tissue and skin are violently stretched; surface blood-vessels are ruptured, and blood is effused.

The severe sickening pain that attends the injury comes from the stretching of the nerves, and not from any peculiar sensibility of the white fibrous structures.

Fracture of bone not infrequently complicates a severe sprain—as the breaking off of the external malleolus when the foot is violently twisted inward; for, under the influence of great force, bone will often yield before ligament or tendon. This is exemplified in fracture across the patella by forcible action of the enormous muscles of the thigh, and in fracture of the olecranon by the sole power of the triceps extensor cubiti.

Of the different joints, the ginglymoid would seem to be more liable to sprain, the enarthrodial to dislocation.

In a bad sprain, the neighboring joints also suffer in some degree, as the knee and hip when the ankle has been severely wrenched. In the presence of the main injury, as Nélaton has pointed out, these complications often pass unnoticed.

The *symptoms* of sprain are pain, swelling, inability to use the joint, and, in most cases, ecchymosis. The pain is often excessive at first, requiring hot fomentations for its relief. The swelling is largely œdematous in character, through interruption of circulation in the subcutaneous structures, mainly by rupture of vessels and the pressure of extravasated blood.

Among the dangers most to be feared in sprain is exaggerated and persistent tenderness of the joint, and consequent inability, or at least unwillingness, to resume its use, causing delay in complete recovery. Hence, a bad sprain is popularly and not incorrectly regarded as about as serious an injury as a broken bone. In fact, lesion of bone, often actually present in connection with sprain, is always to be carefully sought for at the first examination; and this, in justice to both patient and surgeon, as I have already insisted, should be made under the influence of an anæsthetic.

It will be found in some cases, by increased mobility of the joint surfaces upon each other, at first, that there has been actual dislocation—partial or complete—which has already reduced itself. This involves lacera-

tion of ligamentous fibers, or the scaling off of the surface bone to which they are attached. Lesions which have passed unrecognized at first explain, in most cases, the disappointment of tardy recovery from sprain ; and *the responsibility for a faulty prognosis in this respect should not lie with the surgeon.* Whenever there is any doubt as to diagnosis, I again repeat that he should always insist upon anæsthesia, or freedom from subsequent responsibility.

There is a good argument in favor of anæsthesia in the fact that the free but judicious handling of a sprained joint immediately after an injury does no harm, but, *on the contrary, is the source of positive benefit.* This has been fully demonstrated by the good which undoubtedly follows the efforts of the practiced manipulator, or rubber, in relieving pain immediately after the hurt, as well as during convalescence.

Hot or cold applications may be used at first, whichever is most grateful to the patient's feelings. Subsequent treatment will depend upon the diagnosis. According to the severity of the sprain, a longer or shorter period of absolute immobility is, in the great majority of cases, the dominant necessity. When sufficient time has been allowed for union of ruptured parts (and here it is to be remembered that white fibrous tissues heal almost as slowly as bone), then gentle motion and rubbing of the joint may be tried. If great pain follow this trial, immobility may be resumed for a time. Billroth says that since he has put up sprained joints in plaster his results have been very favorable. *The starch bandage applied snugly over cotton batting has given me great satisfaction.* The great advantage of the immovable apparatus in this form is that the patient can ride out, and thus escape the bad consequences of confinement.

The unaccountable sensitiveness which sometimes persists in a joint which has been sprained, even after all unnatural heat and swelling have subsided and

sufficient time has elapsed for thorough repair, is best treated, as far as local remedies seem to be called for, by systematic rubbing, or *massage*, as the French call it, by douches of hot and cold water applied alternately, and by judicious attempts at use. There are no liniments of especial virtue; the good attributed to them is really due to the hand rubbing; to facilitate this the compound soap liniment is the best, or simple vaseline.

But general remedies are often of even greater value. A scrofulous, gouty, or hysterical element in the constitution of a patient suffering from sprain must not be allowed to escape attention, for these influences seriously affect both treatment and cure. A "white-swelling" very often dates its origin from a bruise or sprain. A gouty patient may continue to suffer from pain and tenderness after a sprain until relieved by the administration of colchicum; and many an interesting young lady has been kept in a state of bed-ridden invalidism by the hysterical over-sensitiveness following a sprained joint which has prevented timely resumption of use, in consequence of the too great sympathy of friends—and sometimes also of the surgeon. *I have found the continued current of electricity useful in these cases of hysterical neuralgia which often tax our best skill in their management.*

An elderly spinster had the misfortune to fall on the ice and fracture the lower end of the radius. I put up the fracture in short splints, and in a month got good union, without deformity. A week afterward she came complaining bitterly that something must be wrong in her wrist, for it was constantly paining her. I found nothing wrong as regards the fracture, but her urine was loaded with uric acid, and I bethought myself that I had attended her brother in a fit of the gout. Whereupon I put her on the use of colchicum and alkalies, and she was soon relieved.

Contused wounds come next in order after contusions. Their common features worthy of note are the

similar kinds of violence by which they are produced, and the liability of killing of tissue by crushing. The great practical difference between them is that contused wounds are *open wounds*, and that they heal by the slower and more uncertain process of granulation and suppuration, and not by the prompt and quiet tissue-formation, without pus, with which we have become familiar in the healing of subcutaneous lesions. The best examples to illustrate the difference between a *contusion* and a *contused wound* are a *simple* and a *compound* fracture—when produced by direct violence. A fracture from indirect force, as when the leg is broken by the leverage of the body, as in jumping from a carriage, does not partake of the nature of a contusion; nor does a compound fracture when a sharp fragment of bone is forced from within through the integuments, thus rendering a simple fracture compound. But when a kick of a horse produces a fracture at the point struck by the hoof, whether the soft parts are laid open or not, there is no question as to the character of the injury as regards contusion. It is fair to assume that most bad cases of compound fracture belong to the latter class.

An ordinary *abrasion* or *excoriation of the skin* is the simplest form of a contused wound. Here the external horny layer of the epidermis only may be rubbed off, or its softer layer, the rete mucosum, also invaded, or the papillary structure of the true skin itself may be bruised or destroyed. The first of these simple lesions may scab if the part be kept quiet and protected from further harm; but, when true skin is involved, suppuration is the rule.

When deeper parts are reached by the bruising force, more or less of the skin and surface tissues will have been crushed out of life, possibly also torn or lacerated (for, practically, it is impossible to separate these varieties of injury), and the process of separation of dead from living parts must, at such points, necessarily precede all other efforts at repair. Such wounds are pro-

duced by a fragment of shell, or the tearing of a limb by a round-shot, but mainly by the multifarious contrivances of modern steam-driven machinery, crushing and scalping by cog-wheels and belting, and bruising and laceration in endless variety.

Contused wounds present irregular margins, with flaps of torn and stretched skin and crushed muscle, lacerated tendons, and even fragments of bone. In these wounds there is obvious uncertainty as to how far destruction of life has gone, and in what degree the injured tissues—which may be only half killed—are capable of repairing themselves.

There is little call for sutures and plasters for accurate dressing of contused wounds in hope of primary union. An adjustment only of parts is proper, so as to prevent further harm from isolation or contortion of flaps after the necessary steps have been taken to control hæmorrhage and to remove foreign substances; so also are subsequent means to secure immobility to the part. Usually the wound is protected by some moist, soft material, such as a poultice, water-dressing, or a compress of prepared cotton spread with vaseline. These measures, together with anodynes, if required to secure freedom from pain, and quiet rest to the patient, constitute the ordinary routine treatment.

There is no absolute impossibility in attaining primary union of some portion of a contused wound; in fact, in the vascular and rapidly healing scalp it is the rule rather than the exception; therefore in the dressing an adhesive strap is admissible, or even a point of suture, here and there, to keep parts in their proper relations. But they must be lightly applied; any degree of pressure might interfere with the recovery of parts threatened with death.

Where sand, powder, or other foreign materials are to be removed, use warm carbolized water freely, in a stream from a sponge or a syringe.

A period of some days must follow during which a

contused wound undergoes what has been called the "*process of digestion*," or a cleansing-off of its surface. At the expiration of this time, if everything goes well, bright-red spots or surfaces of granulations will have become visible, covered with yellowish, creamy pus. During the interval that has passed, the discharges from the wound will have been watery and offensive through the presence of dead tissue which is being dissolved, or coming away in shreds, or perhaps in larger masses, such as we call sloughs.

The exact mode by which these sloughs become detached from a still living part is full of interest. In the first place, what is called "a line of demarkation" forms between the dead and living tissues. On the skin, where the process is best observed, this line is irregular, dusky-red in tint, and marked by more or less elevation of the cuticle—a sort of linear blister. On removing the cuticle, a distinct line of separation—in the case of a large slough, a sort of commencing chasm—is visible between the dead and living tissue; on the side of the slough, a livid, discolored surface; on the other side, a line of pinkish granulations—i. e., the raw surface of the living tissues bathed in pus. The chasm results from the shrinkage of the dead parts, and from their partial solution or liquefaction.

On and immediately beneath the surface of the parts which have retained their vitality in a contused wound, the successive changes constituting the process of repair, with which we are familiar, have been quietly progressing, viz.: dilatation of blood-vessels, with increased afflux of blood, exudation, and cell-growth, the latter gradually distending the meshes of the tissue for a line or two in depth, and cropping out upon its surface as a layer of granulations, of which we have already had a glimpse. The object of this new formation is, as usual, to fill up the breach resulting from the wound. As its attainment is obstructed for the moment by the presence of the slough, which adheres until the

granulating surface is complete, the germinating cells which have reached the surface, disappointed of their purpose, are detached as pus corpuscles and floated away in the more watery portion of the exudation. Thus the supply of new material is held in abeyance to await its opportunity.

In this manner the dead tissues are gradually separated from the living—by the vital process set up and carried on entirely within the latter—actually pushed off by the advancing granulations. By the time this process has advanced to the stage of suppuration, the slough, in most cases, has become so loosened from its connection as to be easily detached.

The process just described is more active in the more vascular tissues ; hence a slough will sometimes remain attached to the living parts by shreds of tendon, ligament, or aponeurosis, being elsewhere entirely loose, and perhaps requiring the surgeon's scissors to expedite, at these points, the detachment of an offensive mass. This is the mode by which the surface of a contused wound cleans itself or "digests." It was formerly regarded as an illustration of one of the uses of suppuration.

But, in the advance of surgery, contused wounds, even of the most serious character, can be conducted to a more rapid and safer cure *without suppuration.* Under the *antiseptic* method of dressing wounds now coming into general use, *pus formation can be entirely prevented, the material provided for repair being all reserved for its legitimate uses, and none of it wasted as pus.* This method of dressing, therefore, expedites repair, and economizes both vital material and vital force.

Moreover, by preventing putrefactive fermentation in the parts that necessarily die, it averts the danger of absorption of putrid material and septicæmic poisoning. This is always greater in the earlier days after an injury of this kind, during which fluid matters from the wound can travel along through the meshes of the connective tissue before a barrier of granulation tissue

has been erected. Under an antiseptic dressing the wound is entirely cut off from the external air, and enveloped in an atmosphere of the volatilizable carbolic acid. When fragments of tissue die under this dressing they simply liquefy, and give forth no fetid gases. If avenues of escape are judiciously provided for the fluids that result, there is no impediment to rapid and continuous growth of the granulation tissue into a healthy scar. Under these conditions, which, by skillful and careful management, we can command at will, the process becomes almost identical with that of healing under a scab.

The best mode of accomplishing effectual *drainage*, so as to favor this mode of healing, is by introducing pieces of caoutchouc tubing into the wound before applying the dressing. These should be graded in size and length and number, according to the size and shape of the wound to be drained, and one end, at least, of each piece of tubing should be brought outside in a depending position. If necessary, the wall of a cavity or a flap may be perforated in order to secure a favorable point of exit for a drainage-tube. The external orifice of a tube should be kept free and open, if it tend to become obstructed, by injecting a weak solution of carbolized water through it from time to time. The drainage-tubes should be provided with numerous lateral openings where they traverse the cavity of the wound, and, before being put in place, they should have been thoroughly washed in a carbolized solution. When such tubing can not be procured, strands of horse-hair, common catgut, or even stout waxed hempen thread, may be substituted for it in bundles of from half a dozen to a dozen strands. The decalcified hollow bones of fowls and other small animals make absorbable drainage-tubes, for they may be so prepared as to melt away and blend with the tissues like prepared catgut. Under this mode of dressing, when the drainage ceases through lack of discharge, the tubing or other apparatus

employed for this purpose may be gradually shortened, and finally discontinued entirely, and the wound will be shortly found to be consolidated.

When, after the lapse of a longer or shorter time, under the poultices or water-dressing *heretofore employed*, a contused wound has reached the stage in which its surfaces are fairly covered everywhere with healthy granulations, then its final healing may be expedited by bringing these surfaces in contact and effecting their consolidation by secondary adhesion.

As a rule, contused wounds are not attended by serious hæmorrhage so commonly or to so great an extent as incised wounds, but they involve a peculiar danger, namely, the possibility of serious loss of blood on the final separation of a slough which may have involved an artery of some size. This is the same secondary hæmorrhage that is liable to occur in gunshot wounds —and it is brought about in the same way. When a slough is so situated as possibly to include an artery of size, which may not be successfully obliterated by nature's process, it would be a wise precaution, at the period of danger—i. e., toward the eighth or ninth day—to apply a tourniquet, when feasible, in such a manner that it may be screwed up at once if hæmorrhage should occur, and to teach the attendants and the patient himself how to make pressure upon the main artery of the limb. By this foresight and timely precaution life may possibly be saved. *Lacerated wounds* present most of the features of contused wounds, but have, nevertheless, some peculiarities of their own.

A finger or thumb may be torn off by machinery, dragging out the muscles and tendons attached to their phalanges more or less completely from the compartments formed by the inter-muscular septa.

A man came one day to the New York Hospital, bringing the last phalanx of his index-finger firmly fixed in a large brass screw-nut. While the nut was revolving with great rapidity he had thoughtlessly in-

serted the tip of his finger, when it was drawn in and wrenched off in an instant at the second phalanx, with two tendons attached to it and a portion of the flexor muscular mass.

These wounds are liable to be followed by unhealthy diffuse pus-formation in the thecæ of the tendons, rapidly extending to the palm of the hand, and even to the fore-arm.

The operation of fashioning a stump to the finger in a case of this kind should be done with full antiseptic precautions, and a graduated compress should be applied so as to make gentle pressure along the track of the avulsed tendons or muscles.

No bleeding, as a rule, follows avulsion of a limb, even where large vessels are torn across; the gush is trifling and ceases at once. In the stretching that precedes the laceration of the artery, its inner coats give way transversely and curl inward, as in the hæmostatic device of torsion, and plug its caliber, so that the vessel is effectually obstructed. In the cases in which the whole upper extremity has been torn away by machinery, there has been, in most cases, no bleeding whatsoever; and, when limbs have been torn off by round-shot or shell and left hanging by a mere shred of integument, there has been rarely any hæmorrhage. In a case I once witnessed, in which a rammer's arm was blown off just below the shoulder by the premature explosion of a piece during light artillery practice, the brachial artery, blackened by powder, projected at least two inches from the stump, and was pulsating to within an inch of its torn end; but this was effectually sealed. Such vessels should be carefully and promptly tied at a safe distance on the proximal side of the stretched and injured portion.

Parts which have been violently stretched are liable, subsequently, to slough, either from the injury directly, or from the excessive afflux of blood required for repair, their damaged vitality rendering them unfit for the effort involved in this process.

There is the same tendency to death involving, in rather rare instances, a limb after *contusion*, perhaps of no great severity, coming on without apparent reason and advancing with fatal rapidity—an occurrence always possible, but one which it is not easy always to foresee or to explain.

An otherwise healthy young man was brought into the New York Hospital with a simple fracture of the leg; an omnibus-wheel had just passed over the limb. There was some general shock, and no evidence of more than ordinary contusion in a fracture resulting from direct violence, and very slight displacement. The limb was placed in a fracture-box, and a spirit lotion applied at the seat of fracture. At the morning visit I was surprised to find little or no general reaction, and the leg cold up to the knee, with distinct crepitation perceptible on slightly compressing it. The limb was somewhat swollen and tense, marbled with a peculiar brownish-red tint, with streaks of the same discoloration extending to the thigh along the surface veins and lymphatics. The tibial arteries which had been beating normally the day before could not now be felt. The patient's mind was in a dazed condition, and not working actively. The limb had evidently been stricken with gangrene, and the patient died in a short time with acute septicæmia.

Professor Agnew, of Philadelphia, in his late work on the "Principles and Practice of Surgery," mentions a similar case. "A patient was brought into the University Hospital with a contused and lacerated wound of the fore-arm. The injury appeared to be confined to this part of the extremity, yet in less than twelve hours the entire limb to the shoulder passed into a state of mortification, from which he rapidly sank and died."

In a case of this kind the urine should be tested for sugar. In the diabetic there is but a slight hold on life, and slight injuries are prone to become gangrenous and prove mortal. But there is always a possibility that the main artery of the limb has been crushed and obliterated.

CHAPTER XIV.

Shock and collapse.

In connection with surgical accidents and operations there occurs very commonly a condition I have already mentioned incidentally, and which merits careful consideration; it is known technically as the condition of *shock, or collapse, from injury.*

Shock is not only of common occurrence, but it presents phenomena of a curious and interesting character, with which the well-trained surgeon should be entirely familiar. This condition may vary in degree from the slightest lowering of the vital powers to complete and total abolition of sense and sensibility.

When we say of a person who has been the victim of an accident that he is "suffering from shock," we mean that he presents a depression or obscuration of the ordinary manifestations of life, and that this has come upon him suddenly and directly from the impression produced upon the organism by the injury. When the depression of the vital powers is serious and continued, we speak of the condition as *collapse*, meaning a collapse of energy, a suspension of the life-force—such as might follow an arrest in the supply of the nerve-force generated by the nerve-cells of the gray matter of the nervous centers. The effect of the injury has been, in fact, to suspend temporarily, perhaps, if sufficiently severe and concentrated, to abolish entirely and instantaneously—as in death by lightning—this wonderful phenomenon of the generation of nerve-force by nerve-cells.

In the case which Professor Tyndall quotes to prove the absolute unconsciousness of pain in this mode of death, a soldier, being overtaken by rain, took refuge under a tree beneath which a woman had previously taken shelter. He looked upward to see whether the branches were thick enough to afford the required protection, and, in doing so, was struck by lightning, and fell senseless to the earth. The woman at his side experienced the shock in her foot, but was not struck down. Some hours afterward the man revived, but remembered nothing about what had occurred save the fact of his looking up at the branches. This was his last act of consciousness, and he passed from the conscious to the unconscious condition without pain.

The effect of the injury here was directly upon the nervous centers; the other visible marks of a lightning stroke, as we gather from this authority, are usually insignificant. The hair is sometimes burnt, slight wounds are observed, while in some instances a red streak marks the track of the discharge over the skin.

If this man had died outright instead of reviving, it is doubtful if any morbid changes could have been found to explain the sudden abolition of life, unless indeed in the nerve-cells of the brain, by the microscope or chemical scrutiny. Death by lightning is an example of instantaneous mortal shock, and it conveys the best idea I can give you as to the direction in which the changes causing cessation of life are to be sought for, and the pathology of the condition explained.

In cases of shock arising from less intense injury, death, if it occur at all, comes by gradual extinction of the action of the heart, through failure in renewal of nerve-supply from the nerve-centers.

In ordinary examples of collapse, recovery or *reaction*, as it is technically termed, takes place spontaneously, as in the man struck by lightning, the nerve-cells gradually resuming their function of generating nerve-force. It is within our capacity, in some cases of

shock, to employ means which have the power of stimulating the flickering vitality and of determining the issue in life or death ; but in the vast majority of instances reaction takes place, as I have said, by spontaneous resumption of the vital processes. Hence, commonly, it is the duty of the judicious surgeon simply to remove all causes of continuance of shock, to secure the most favorable surroundings for his patient, and to await the result, for there is danger in violent reaction from shock. The temptation to employ more active means to promote reaction is, therefore, to be resisted, unless unmistakable indications present themselves. What means may then be used with advantage we shall shortly determine.

The more common and immediate *causes* of well-marked shock, as it is encountered in surgical practice, are extensive burns, the crushing of limbs by machinery, severe or protracted surgical operations, a penetrating wound of the chest or abdomen, or, in short, any sudden and important injury, especially a gunshot wound. Injuries of certain organs—the sexual, for example—and certain kinds of wounds, are more liable to be followed by shock when they are really not severe ; castration, the injection of an irritant into the tunica vaginalis, the simple introduction of an instrument through the urethra, are instances in point; and a man struck by a bullet will often fall to the ground, even when no important organ has been wounded.

It is not the *pain* alone that produces this effect (although pain is capable of depressing the powers of life, as by shock), because a slight gunshot wound—producing, indeed, a mere flesh wound, say of the arm, and causing little more pain than the contact of a pebble—has been followed by all the well-known symptoms of shock; and a soldier has even sunk to the ground not knowing that he has been wounded. It is also obvious, therefore, that *fear* alone does not produce the muscular relaxation. It would seem that the *suddenness* of

the injury has something to do with the shock that follows a surgical accident.

The ordinary *symptoms* of shock—let us assume, for example, in a middle-aged man who has just been run over by an omnibus and sustained a simple fracture of the thigh—are: a half-stunned and bewildered condition of mind; a decidedly pallid and cool surface, with cold sweat on the forehead; a weak pulse, usually frequent; irregular, shallow respiration, with an occasional sigh; indisposition, in fact, inability, for muscular effort. The patient lies in a sort of apathetic semi-stupor, but, if his injured limb is rudely handled, he will complain. If he has eaten shortly before the accident, he may vomit. Very likely when, after a time, the desire comes to pass water, he will find himself unable to accomplish the act.

Let us assume a case of graver injury attended by *extreme shock* threatening life, where, for example, a bullet has traversed the cavity of the abdomen, or a knee-joint has been crushed in a railroad injury. Here you will find your patient lying perfectly limp and relaxed, entirely powerless to change his position—a picture of utter prostration. The pallid face presents the aspect of death, with eyes half-closed and rolled upward so as to show only the whites, the lips pale and bluish, the features pinched, the forehead bedewed with drops of sweat, and the whole surface moist and cool. The pulse at the wrist is perhaps imperceptible, and the slow and feeble beating of the heart only recognizable by an ear applied to the chest. The complete relaxation of all the voluntary muscles is indicated frequently by a fecal odor, suggesting that the sphincter ani has failed in its duty. In a word, the patient lies "pale and motionless, as indifferent to the outer world as if the injury had already terminated in death." And yet, although sense and sensibility are so entirely overwhelmed, he can probably be aroused so as to swallow.

These symptoms of shock we should analyze in order

to get at their exact significance. But, meanwhile, let us glance at some of the milder phases of shock, and some conditions which resemble shock in their manifestations, which have been called by some "limited shock."

A slight twist of the ankle from a misstep, causing no serious injury, will often render a person momentarily dizzy, faint, nauseated, and utterly unable to move the part for some minutes. After a fracture, a patient is often unable to empty the bladder. Many men are unable to pass water in the presence of another. In the condition known as "stage-fright" there is often pallor and cold sweat, with inability to command the faculties ; and in sudden alarm or anxiety there is dryness of the throat from temporarily arrested secretion in the follicles of the fauces, so that an effort is required in swallowing. In fact, a sense of extreme danger distinctly begets muscular relaxation.

Millingen relates of the Guards at Waterloo, who were kept so long exposed to the French fire before the order came to charge, that those killed in the ranks, while waiting, were mostly found with their clothing soiled. The Edinburgh surgeon who confessed that he always had a diarrhœa before a serious surgical operation, offers a mild example of a similar influence.

Death from rapidly advancing acute disease, or when life is threatened by internal injury, is hastened and preceded by shock—as in perforation of the pleura by a softening tubercle, the sudden occurrence of strangulation of a hernia, or peritonitis from perforation. The *moribund* condition in many cases presents a strong resemblance to that of collapse. The depression attendant upon nausea, from whatever cause, is hardly distinguishable from that caused by an injury ; there is the same diminished vigor of the heart's action, attended by pallor, a moist surface, and muscular relaxation.

Before the use of ether and chloroform in surgery it was a common resource, in order to facilitate the reduc-

tion of a dislocation, to administer tartar-emetic, or to inject tobacco-smoke into the bowels of a patient unaccustomed to its use, which rarely failed to produce muscular relaxation. Certain poisonous drugs beside tobacco give rise to the phenomena of shock, such as colchicum, the poison of the upas, apomorphia, jaborandi, and hydrocyanic acid.

The influence of the mind upon the body is a most important factor in causing the physical symptoms of shock, and often in explaining their presence. I have already alluded to the depressing effect of fear, and given examples of it. The bravest are not beyond its influence; true courage, in fact, consists in persistently facing danger after fully recognizing its extent. In many a case the effect of fright, even from an imaginary cause, has produced all the symptoms of collapse—the patient being "more frightened than hurt." It is well to know that instances of absolute death from shock through mental emotion alone have been occasionally recorded.

It is easy to understand, therefore, why a word of encouragement from the surgeon in whom a patient has confidence calms his agitation and brings back the color to his cheek; and how the quieting influence of opium restores his courage. The constant effect of the anæsthetic upon the pulse of a patient about to undergo a surgical operation, in rendering it less weak and rapid, in restoring, in part at least, the calm vigor of the heart's action as soon as the unconsciousness of the brain has released it from the depressing sense of coming danger, demonstrates to us daily this intimate relation between the brain and the heart.

And this curiously sensitive center of circulation, this all-important organ whose action the surgeon so closely watches, is just the point in the organic machinery at which the effect of shock first manifests itself. The paleness of the face, the coldness of the surface, the stifled breathing, the arrest of secretion as shown

in dryness of throat and huskiness of voice, are all explained by the withdrawal of the force that impels the blood toward the capillaries.

But shock may possibly affect the heart through the spinal nerves without any cerebral consciousness. Erichsen tells us that the sudden crushing of the limb of an anæsthetized dog, in an experiment, sensibly slowed the action of its heart.

The heart, therefore, although possessing inherent muscular contractility, and provided with ganglia or nerve-centers of its own, is always liable to be affected as to its action by physical influences conveyed to it through cranial and spinal nerves, as well as by mental emotion. This is demonstrated fully by experiments on animals. Frogs, whose webs had been previously displayed under the microscope, have been subjected to sudden crushings of different parts of the body by a hammer, and in every instance temporary arrest of the capillary circulation in the web followed. When reaction took place, it was found that for some time the blood only circulated in the larger trunks up to the capillaries, but not in them, in consequence of the still weakened action of the heart. In one instance the head of a frog was suddenly and completely crushed by a heavy blow, causing instantaneous arrest of the capillary circulation in the web; but within half an hour the current in the capillaries began again, showing that the heart had recovered from the shock received through the cranial and spinal nerves, and had resumed its pulsations by virtue of its intrinsic nervous and muscular force resident in the cardiac ganglia, which was still unexhausted.

In another experiment, the lower half of the spinal cord of a frog was removed, and, in addition, both sciatic nerves were thoroughly divided, so that the lower limbs were completely isolated from the brain and heart, except through the blood-vessels and the sympathetic fibrillæ accompanying them. After the web of one foot

had been displayed under the microscope, the other limb was then severely crushed, but no change whatever was manifested in the rate of the circulation. It was thus rendered evident that shock is conveyed to the heart through the cerebro-spinal nerves and not through the sympathetic, which, of course, closely surrounding the arteries, remained intact.

It is well to know, as showing the tolerance of injury in cold-blooded animals, that, if the operation be slowly and carefully performed, both the brain and spinal cord of a frog may be completely removed without stopping the action of the heart. It may be inferred from this that the circumstance of *suddenness* in the infliction of an injury has its share of influence in causing the shock that follows.*

With these evidences of cardiac impressibility by causes capable of producing shock you are prepared to adopt this important truth—which is of great value to the surgeon under many circumstances in practice—*that, as long as the heart is acting well, the condition of shock or collapse can not exist;* and the circumstance is explained why, when the surgeon first approaches a wounded man, his first impulse is to feel his pulse.

It is probable, as Jordan says, that the first effect of shock upon the heart is always to render its action slower as well as less forcible; and that the subsequent increase of frequency, which is correctly attributed to diminished force, is due to the reactive effort which almost immediately follows.

The tracing left by the sphygmograph of Marey, applied over the radial artery during an amputation—say of the leg—gives a much more accurate record of the heart's behavior during shock than the impression we receive through the fingers upon the pulse. This instru-

*I am indebted for many of these experiments to the prize essay on shock of Dr. Furneaux Jordan, of Birmingham, England, published in the "British Medical Journal," 1867, vol. i.

ment demonstrates the occurrence of the initial slowing and the subsequent rapidity, which latter suggests what is probably true—*that the heart is trying to make up in frequency what it has lost in force.*

Besides their immediate and manifest influence upon the heart, the effects of pure shock are also keenly felt by the *brain* (as shown by the dazed and slowly acting condition of the perceptive faculties), and by the *spinal cord* (causing the relaxed state of the voluntary muscles), and by the *organs of special sense*, which are dulled in their functions, but by no means extinguished. The effects of shock are also promptly transmitted through the spinal nerves to the organs of respiration, assimilation, and secretion, accounting for the shallow breathing, the occasional nausea, and the dryness of the throat.

The *clammy sweat* that covers the surface of the body in collapse is not the result of hyper-secretion, but of exudation of pre-existing secretion forced out of the passive sweat-ducts by the cold, shrinking skin ; and the *dry mouth and husky throat*, and the consequent effort required in swallowing under the shock of sudden terror, clearly attest the stoppage of secretion. *Collapse of muscular energy* is the result of want of blood and nerve-supply to muscular tissue.

The peristaltic action of the bowels, effected by unstriped muscular fibers, under the control of sympathetic nerves, is less influenced in shock than the contractile power of the sphincter ani, which is a voluntary muscle, and, like all the muscles of animal life, liable to be relaxed. Moreover, it requires more exertion of muscular force and concentration of mental effort to prevent the contents of a full rectum from escaping than it does to extrude them. Hence under the full influence of shock there will be involuntary escape of fæces whenever the rectum is distended. In the case of the bladder, on the contrary, more effort is required to extrude its contents than to retain them ; hence there is

retention of urine from sheer inability to make the effort to void it, as in typhus fever.

The *fever and excitement* which not uncommonly attend reaction from shock are perhaps best explained, as I have already hinted, by the chemical disturbance which (while the vital forces were in abeyance) has taken place in the albuminous compounds of the blood.

The most delicate point in connection with the *diagnosis of the condition of shock of injury* is to separate its phenomena from those of syncope. I have already alluded to the fact that the symptoms of *concealed hæmorrhage* are often mistaken for those of *shock*. It is usually assumed, in fact, that the immediate consequences of copious loss of blood are in reality those of shock—the diminished quantity of the circulating fluid depressing for the moment the heart's action, and thus influencing the nerve-centers. Travers says: "A fit of syncope and the recovery from it present an epitome of the phenomena of shock."

But where syncope occurs otherwise than by loss of blood—as, for example, where an apparently strong man falls into a "dead faint" in a dentist's chair from the simple lancing of a gum-boil—there are points of difference to be detected between his condition and the shock of injury. I should say that the abolition of the sensory function—of the intelligence—was for the moment more constant and complete in syncope, and that the effect upon the brain was greater in proportion to the severity of the injury. Contrast the condition of so-called "dead faint" from a comparatively trivial impression, such as that I have just instanced, or from that which may follow the first introduction of a catheter, with the state of a person whose leg has been crushed by machinery. This man with the crushed leg is cold, his heart is scarcely acting perceptibly, he is dazed, has a wild, vacant stare, has no self-command, but, unless there has been also some injury to the brain, he will respond to questions—after a fashion; his organs

of sense are obtunded, not abolished; and, if his crushed limb is handled roughly, he will complain of pain; he is not in any sense in a dead faint, as in the case of so-called syncope from slighter hurt. The one suffers entire suspension of sense and power of motion, yet in a few minutes—sooner, if his head is made to hang down and his feet raised—he will be, to all appearance, as well as ever; the other retains both consciousness and sensibility in an imperfect state, but he will not react perfectly for an hour or two at least, if indeed then, for perhaps he may sink into utter collapse and die.

The symptoms of hæmorrhage from internal injury—as from laceration of the liver—have already been mentioned as resembling those of collapse from shock. When the two co-exist and death follows, it is not always easy to decide without opening the body. Death by hæmorrhage, if it takes place slowly, is marked by revival of strength from time to time, with intervals of profounder syncope; is attended by well-marked sighing respiration, frequently by temporary loss of vision, and always by great thirst, which symptoms do not occur in mortal shock. In shock the sinking is more steady and gradual.

When we consider how carefully nature has protected the nerve-centers by suspending them in fluid surroundings, by supporting them, *as it were, upon a water-bed*, and by isolating even the minutest nervous filament, we recognize that danger of injury to this delicate tissue—in other words, of shock—has been guarded against, as far as physical violence is capable of producing it. But there are causes originating in the nerve-centers themselves, against which there is no protection, capable of producing shock as fatal even, in rare cases, as that caused by the electric fluid. I refer to the instances of sudden death, already mentioned, from *mental emotion*—from excess of joy or terror.

Of this mysterious reaction of the mind upon the body we can offer no adequate explanation, and we

must simply recognize the fact that *it is competent alone to cause all the phenomena of shock*, and, moreover, that it is always present in some degree, complicating, modifying, and often intensifying the effects of shock produced by physical causes. The amount of this *psychical influence* in a given case of shock we can not always certainly determine. I have seen an impressible woman of hysterical temperament fall senseless on receiving sudden bad news. This was an example of shock of purely nervous origin.

Next to purely nervous shock, that resulting from injury applied directly to the head, and complicated by it, is the most difficult to distinguish. We have seen that the phenomena of shock are due to *arrest of the generation of nerve-force by the nerve-cells of the gray matter of the nervous centers*—in consequence of sudden injury inflicted upon the organism ; that these phenomena or symptoms of shock, shown mainly in diminished action of the heart, are also greatly modified by the influence of the brain, especially as regards the *diagnosis* of the condition and its *prognosis* as to danger. I told you, for example, that a blow upon the head with a slung-shot, or even a sand-bag, will cause a man to drop as suddenly as though a rifle bullet had passed through his brain. This result is produced by the instantaneous arrest of consciousness through the effect of concussion, perhaps also of compression, of the brain—not by shock alone.

With injury of the head complicating shock we shall recognize a tendency to predominance of head symptoms, such as mental incoherence, spasm, or convulsions, sluggishness or inequality of the pupils, stertorous breathing or coma, while the heart shows proportionately less evidence of disturbed action. The heart is here shielded more or less from shock in consequence of the suspended function of the brain, just as we have seen a rapid, feeble pulse improve in quality under the administration of an anæsthetic.

According full weight to these facts and considerations illustrating the nature of shock and its diagnosis, we must be prepared to find that the symptoms and effects of shock are modified in their aspect and details by other causes besides the nature of the injury—such, for example, as the age, sex, and constitution of the patient, and pre-existing disease.

Shock occurs more readily in a child than in an adult, through the greater impressibility that belongs to this time of life. In consequence of the activity of the vital processes, it is also more quickly recovered from. Hence delayed reaction in a child, as we see exemplified so often in bad cases of burns, means no reaction—i. e., death. On the other hand, in advanced age shock does not occur so readily, but, when it does take place, reaction is slow and feeble, but nevertheless often satisfactory.

Women behave under causes of shock more as children; they are impressible, but they rally well. *The influence of the mind, and often the hysterical element, is more likely to predominate in the sex,* rendering prognosis less serious in proportion to apparent gravity of symptoms. *But, although lacking in physical strength, women as a rule excel the stronger sex in capacity for endurance of pain.*

Favorable reaction from collapse is liable to be prevented or delayed by pre-existing disease of some vital organ. There are no circumstances in which thorough training in physical diagnosis confers more power than in cases of surgical injury where such a complication as this is present. Although the actual condition of shock is unfavorable to exploration, no effort should be spared, as opportunity offers, to get exact information as to the condition of the brain, heart, lungs, liver, and kidneys.

In estimating the capacity for bearing a surgical operation, which is so often an urgent question, the knowledge gained in this way from a patient who has

just suffered from an accident is invaluable. When amputation is inevitable, as, for example, after crushing of a limb by the wheel of a railroad-car, in the interval while reaction is being awaited, the patient's history and habits should also be investigated, by inquiries from friends, as far as possible. If any urine be voided, let it be carefully preserved and promptly subjected to examination. It is obvious at once how greatly the patient's fate would be influenced by the discovery of diabetes or Bright's disease, of phthisis or heart-lesion, or *by reasonable proofs of their absence.*

Extreme cold causes death by gradual depression at the same time of nerve-force and blood circulation, accompanied by an irresistible desire to sleep. This is regarded by some as a variety of death by shock. So also is death by sun-stroke or insolation, in which the nerve-centers have become heated to a degree incompatible with the generation of nerve-force, and therefore with life.

The peculiar features which belong to *shock from railroad accidents* have become familiar to surgeons through rapidly accumulating experience, mainly within the last forty years. Before the universal adoption of this mode of land carriage, the human body was not likely to be acted upon by such enormously accumulated mechanical force driven with so great velocity; so that in reality a new class of surgical injuries has been introduced, which act proportionally in a greater degree upon the nervous centers.

The results of railroad collision in the way of shock are commensurate in severity with the amount of force, and also with the velocity with which it moves. They present three principal peculiarities: (1) they are not so often directly fatal as the magnitude of the force and its suddenness would lead us to assume; (2) their effects often continue unaccountably after other injuries received at the same time have got well; and (3) the

spinal column and cord seem to bear an undue share of the injury.

Thus chronic infirmities in the form of feebleness, both in mental manifestations and bodily motions and sensations, notably of the lower limbs, often follow the violence sustained through railroad collisions. Recognizing, as we do now, the true pathology of shock, we can understand *how such rude commotion of nerve-cells might cause at the time their permanent disorganization, or give rise to their subsequent degeneration.*

The term "chronic shock," applied to the condition of disability following railroad injuries, is obviously a misnomer. We can well understand, however, that this sort of injury of the delicate texture of the nervous centers may prove to be the starting-point, or source, of progressive disease of brain or cord.

The sitting position, in which the shock is most commonly received, would seem to afford an explanation as to why the spine and cord suffer in undue proportion.

Death in uncomplicated shock takes place by asthenia, through gradual failure of the heart. Muscular twitching and convulsive action occur exceptionally. After the double shock of an injury and a subsequent operation, death sometimes follows a primary amputation with symptoms which are neither those of shock, nor of hæmorrhage, nor of a combination of the two, *but which have been ascribed to irreparable injury to the life of the blood as a tissue—the condition which has been called "necræmia," in which the life of the blood-cells has been extinguished by chemical changes in the liquor sanguinis.*

I was once compelled to remove the lower extremity of a female child of nine years of age who was brought to the New York Hospital. The wheel of a street car had passed over it obliquely, leaving barely room for amputation at the hip-joint, which, as excellent reaction had already taken place, it was decided in consultation, offered her the only chance for life. There was fair

reaction after the operation, at which the loss of blood was very moderate. But the child lay more than twenty-four hours torpid, listless, with a dry tongue, a moderately warm skin, and a very rapid pulse, which gradually became imperceptible as she died.

After death by shock the blood usually remains fluid, or only partially coagulates. Decomposition begins early, and tends to advance rapidly. This is because the principle of life has been first extinguished in the constituent microscopic cells of the tissues. Under ordinary circumstances, *somatic* death (i. e., death of the body as a whole) precedes molecular death (i. e., death of the microscopic elements, like the leucocytes, which possess a life of their own) by a variable but distinct interval of time. Thus the phenomena of ciliary motion, and also of muscular contractility, are known to survive the death of the body for a longer or shorter time; * and, while cell-life persists, decomposition is resisted. After death from pure shock there is no lingering textural vitality and no such barrier to chemical supremacy, and it is at once asserted by evidences of decomposition.

In *reaction* from shock *there is a commencing increase in the temperature of the body*. The *thermometer* in shock, which has not been much observed, usually falls one or two degrees below the natural standard. When shock is complicated by hæmorrhage, the fall in temperature has been noticed to be decidedly greater; and in a case of cut throat observed by Le Gros Clark it reached the remarkably low figure of 91·2° an hour after the injury. The man in this case recovered.

A rise in the temperature is, therefore, to be welcomed as the first indication of an ability to rally. It has been remarked that those cases of reaction are always attended by most doubt in which the temperature keeps low. In natural, kindly reaction the surface

* The muscles of an amputated leg usually contract when pricked, but not after shock.

dries and gets warm; the patient gradually assumes a natural attitude, breathes more deeply and regularly, and tends to fall into a natural sleep. These evidences of improving condition are often immediately preceded by vomiting, in case the stomach contained food at the time of the injury.

On awaking, the intelligence is clearer and the expression more natural; friends are recognized, and food or drink asked for. When symptoms are thus favorable, the injury causing the shock has not been extremely severe; reaction will probably have begun within the hour, and the improvement will go on steadily until the standard of health is reached.

But, where there is a grave and painful injury, complicated possibly with hæmorrhage, reaction will be delayed, perhaps for many hours; or, after having fairly commenced, it may falter and recede, the patient relapsing into prostration—a circumstance always suggestive of internal hæmorrhage; or reaction may fail entirely, and death become imminent.

We have next to answer these questions: By what means can we antagonize the effects of shock and prevent an unhappy result? How far can we trust to the unaided resources of nature? To the latter question I would answer that, in moderate shock, nature can be trusted to a much greater extent than is generally believed. The pitiful aspect of the patient, suggestive of immediate dissolution, invites prompt efforts for relief, and usually begets officiousness on the part of the kind-hearted, which is not infrequently productive of harm. The wisest measures, at first, are to place the patient in a retired and quiet place and in an easy position, with the head not too high, and *then to take means to preserve the warmth of the body.* Simpson's suggestion of soda-water bottles filled with hot water, and a woolen sock drawn over each, to be placed in contact with the body, is eminently practical. If the patient can swallow, a few teaspoonfuls of hot spirit and water may

be administered—carefully, lest it get into the windpipe; little by little, as the pharynx can dispose of it. But the quantity must be limited; more than two ounces of brandy might cause vomiting. If pain is present, paregoric may be added.

Alcohol is certainly the most available stimulant for the failing heart, and, if the danger of sinking is really urgent, two ounces of spirit may be also thrown into the lower bowel, diluted with a gill of strong hot coffee or beef-tea. But the spirit should not be too soon repeated. A mustard-plaster over the epigastrium may render the stomach more likely to absorb the stimulant. Ether in vapor, sparingly inhaled, acts as a stimulus; so also does ammonia added in moderate dose to the brandy; and the injection of dilute ammonia into a superficial vein has produced remarkable effects in apparently desperate cases in the hands of Dr. Gaspar Griswold.*

In animals, where the heart's action has been arrested by removal of the nervous centers, artificial respiration has started it again; it might do the same in man when death from shock is imminent.

If pure oxygen is at hand, blood corpuscles charged with it might convey more stimulus to the heart than that derived from breathing simple atmospheric air. Electricity possesses stimulating power, and, according to Savory, has served a good purpose when the heart has been stopped by a blow upon the epigastrium. It has been proposed to thrust acupuncture needles into the heart. Virtue has been ascribed to the contact of warm animal tissues—as, for instance, to the skins of freshly slaughtered animals—the horse, for example, as employed by Baron Larrey in the case of Marshal Lannes, who was shot through both legs at the battle of Austerlitz.

In our efforts to avert death from shock we must always keep in view the fact that its immediate cause

* ʒj of equal parts of aqua ammoniæ and water ("Record," July, 1877).

is failure of the heart's contractions through lack of nerve-supply. After death the heart is found gorged with blood which it has been unable to force onward. In this view, Savory's recommendation to tap the external jugular vein is rational, for it might relieve the condition of paralysis resulting from over-distention. The operation of transfusion, also, when hæmorrhage has aided in deferring reaction, might possibly prove of service.

In cases where immediate danger to life is not the supreme consideration, I will repeat that great caution in giving alcoholic stimulus in collapse is always to be observed, for the following reasons: (1) In the great majority of cases reaction will certainly occur through the efforts of nature alone, aided by position, external warmth, moral encouragement, and a moderate anodyne. If the shock be very severe, the danger of complication by internal hæmorrhage is proportionally greater; and, therefore, (2) the action of stimulus upon the heart would be likely to excite bleeding from wounded vessels which, if the circulation remained languid, might be permanently closed by nature's hæmostatics. Danger from this cause, and also from over-excitement in reaction, is especially to be feared when, simultaneously with shock, there are also evidences of injury to the brain. Stimulus is more likely to be required where the main force of the shock has been borne by the heart, and where, after a reasonable time, the pulse does not grow stronger and diminish in frequency. (3) The recovery of bruised and injured parts will be favored by a languid circulation; and the formation of noxious chemical combinations of organic compounds, which by being absorbed into the blood might cause fever, is less likely to occur when the circulation is not stimulated. In short, Bryant's rule in the treatment of shock is eminently judicious—"*to do enough to maintain life is essential; to do more is dangerous.*"

Now, after recovery from shock, a condition often

succeeds which surgical writers describe as *excess of action with lack of power*, the lack of power being due to defective generation of nerve-force by nerve-cells, and the excess of action nothing more than the effort on the part of the heart to make up in the frequency of its contractions for their defect in force. Whatever depresses the nerve-power of the heart tends to make it beat more rapidly—even the passing influence of tobacco.

In consequence of over-stimulation, indeed often without it, the debility of collapse is liable to pass, during reaction, into the other phase of depressed vitality which we call fever. The pulse may acquire more force, but its frequency continues; and the natural warmth of the skin, which has returned, goes on increasing to fever heat. The brain also may give evidence by symptoms of delirium that it has not yet recovered its full power.

Reaction merging into fever means that it is incomplete and halting. It is important not to fall into the popular error that the reaction has passed beyond the boundaries of health into the region of "inflammatory excitement," and *that it requires remedies of a lowering character.* The excitement, in truth, is due to depression of the powers of life; it is in the great majority of cases the condition of "*prostration with excitement*," so well described by the English surgeon, Travers, fifty years ago. It demands a careful continuance of the *expectant* treatment, which should always be carried out during reaction, with the addition of absolute quiet, nourishment in small quantities as the stomach will bear it, and an attitude of patient watchfulness on the part of the surgeon.

If sudden mental emotion can so change the character of a mother's milk as to render it poisonous to her child, the stagnation of all the vital processes that accompanies profound shock may well beget analogous blood changes capable of causing fever. Billroth, Bur-

don-Sanderson, and our countryman, Horatio Wood, regard chemical blood changes as the most probable cause of fever. Jordan assumes that the blood may be rendered poisonous by shock, and speaks of its altered condition as favoring thrombosis and embolism, and of causing what he calls the "ichorrhæmic form of pyæmia."

Sometimes in connection with reaction, instead of vascular excitement, the *nervous symptoms predominate;* in place of the hot skin and quick pulse of fever, the skin remains cool and the pulse weak, but nervous excitability manifests itself, attended by delirium—sometimes of the wildest kind. This is the *traumatic delirium*, first formally described by the French surgeon Dupuytren. It is a condition rather of apparent than of real danger, partaking somewhat of the nature of hysteria. The best remedies are Hoffmann's anodyne, and nervous stimulants, or opium.

Again, where a person who has been the subject of a serious accident is an habitual drinker of spirits, reaction may gradually merge itself into the peculiar condition of the brain called *delirium tremens*, with its startled, sleepless watchfulness, and its strange delusions. In this event a temporary return to the accustomed stimulus in moderate but sufficient quantity, with bitters and nourishment to keep the stomach acting steadily, and digitalis and opium to procure sleep, is the best treatment, *not omitting the constant watchful supervision of a trained nurse.* I have known a patient with his leg in a fracture-box leap from his bed, in the temporary absence of the nurse, and scuttle around the ward to escape an imaginary pursuer. As in maniacal excitement, there is often complete insensibility to pain.

Concerning the grave and important question so often presented to the surgeon as to the propriety of amputating during shock, there is a word to be said in this connection. Before the great American discovery

of anæsthesia, the temptation was undoubtedly great, in a case of injury to a limb so severe as to require its sacrifice as the only chance of saving life, to remove the limb during the stupor of shock. The extreme necessity apparently justified the great risk, and an occasional success seemed to confirm the propriety of incurring it. John Hunter speaks of the "stimulus of the knife," an ominous expression that conveys an idea both of the gravity and of the narrowness of the issue at stake. Now, since this great boon to surgery of ether and chloroform, it is our privilege to be able to await more perfect reaction, for *we have it in our power to produce stupor safely at will.* Experience has taught us that carefully induced anæsthesia, especially with ether, does not usually impede reaction, and that it certainly mitigates the second shock liable to follow an operation. So that it is the rule at the present day that *the operation, when unavoidable, should be done as soon as the temperature has begun to rise and the pulse to recover its force; in other words, as soon as it is demonstrated that the system is capable of reacting from the injury.* This is the proper time to introduce the anæsthetic, and, as Ashhurst judiciously remarks, if the pulse improves under its gradual administration, this circumstance is to be regarded as an indication in favor of operating. On the contrary, if the pulse falter under the ether, there is probability of internal injury, or hæmorrhage, which rather forbids interference. In other words, as we can now safely produce artificial stupor when the danger is less urgent, we are no longer tempted to take advantage of the stupor of collapse, with the greater risks that attend it.

The *presence of hæmorrhage from an injured limb*, even though trifling, and especially if it require painful manipulation for its control, is a good reason for avoiding delay in amputation.

Increasing familiarity with the conditions of heat production in the body will no doubt aid the surgeon,

by means of the thermometer, to base his judgment as to the proper moment of operating upon more unfailing indications. In Jordan's experiments with the thermometer during amputation of the thigh, covering more than twenty cases, there was no variation produced by the chloroform, nor yet by the cutting of the soft parts. In the experiments of Le Gros Clark at St. Thomas's Hospital, London, these general results were confirmed. With the thermometer, therefore, and the sphygmograph to measure the pulse more accurately, we have instruments of precision which render it a much less difficult duty to decide upon the proper moment for operation.

Of course, as in all cases of suspended or obscured consciousness, there is more or less difficulty in ascertaining the exact condition of the brain, but it is a good rule, whenever there is a question of shock, to adopt expectant treatment. Shock will usually fade out and leave cerebral symptoms, if present.

CHAPTER XV.

Poisoned wounds.—Dissection and serpent virus.

WOUNDS of any kind into which a poison has been introduced at the time of their infliction are known in surgery as *poisoned wounds:* those made by the poisonous insects—the mosquito, hornet, wasp, scorpion, etc., the inoculation of chancroidal virus, dissecting wounds, the bite of a venomous serpent or of a rabid dog, are examples.

Poisons may be absorbed, also, through pre-existing wounds, abrasions, and cracks of the skin; in this way anthrax or malignant pustule, glanders, syphilis, and other infectious diseases may be communicated.

Although the epidermis possesses protective qualities, there is reason to believe that some of these poisons may be absorbed, exceptionally, through the unbroken skin or through a mucous membrane. Sir James Paget gives an account of a very severe illness which he contracted in making a post-mortem examination of a case of pyæmia, in which he suspects that the material by which he was poisoned was in the pleuritic fluid in which his hands were long soaked. "Whatever the virus was," he says, "*it soaked through my skin; I had no wound or crack of any kind.*" ("Clinical Lectures," etc., New York, 1875, p. 322.)

These conditions, as to absorption, etc., are all necessarily included under the head of *poisoned wounds*, which comprises, therefore, a wide range, including at the same time the most trivial and the most fatal of surgical affections.

But considerations of still greater moment present themselves inseparably in this connection concerning the nature of the different poisons thus liable to be introduced into the body; for the *traumatisms* themselves sink into insignificance in comparison with the poisons with which they are associated. These poisons just now command a keener interest in consequence of recent discoveries and the promise of successful treatment growing out of them, which have brought the subject of blood-poisoning into the front rank as *the most prominent subject in surgical pathology.* In other words, we can not satisfactorily study poisoned wounds and speak intelligently of poisons without raising questions as to the meaning and value of the terms "septic" and "antiseptic," and as to whether these toxic principles originate in new chemical combinations in the fluids of the body itself or in the action of septic substances or microscopic germs introduced from without. However difficult it may be to discuss fairly questions which are still under judgment without becoming partisans, nevertheless, in order to master the principles of surgery at the present time, it is incumbent upon us to make the effort.

We shall be better prepared to do this after devoting a little time to some of the more important poisoned wounds, and thus the effects of certain at least among these poisons will be illustrated. From these effects we may be able to form some idea of the source and nature of the poisons, and of their endless variety.

Among poisoned wounds there is one variety which has especial interest for us in connection with the study of anatomy from the dead body; I refer to *dissection wounds.* There are traditions of danger from this cause which are all the more impressive in consequence of the obscurity as to the exact source and nature of the poison which constitutes the element of danger.

The recorded cases of serious consequences following wounds received in dissecting or handling the dead

body may be grouped in several classes, of different degrees of severity: First (local), where a prick or cut of the finger is followed by anomalous symptoms, such as excessive pain, persistent swelling—with or without suppuration—and a disposition to local death rather than to healthy and normal repair. Second (general), where glandular tenderness and local suppuration are developed in the upper arm, axilla, or beneath the pectoral muscle of the wounded side, with or without diffuse pus formation among the muscles, and with fever of a low, continued type, showing that the poison, no longer local, has invaded the organism. Third, where, in addition to the latter features, pleuritic or peritoneal effusion takes place, with symptoms of fatal septicæmia, showing that the blood has become poisoned. Finally, in some cases there are unhealthy abscesses and pustules and *local* warty growths developed on the hands, mostly upon the dorsal aspect of the phalanges.

Since the measure has been adopted of injecting subjects for dissection with a conservative chemical solution (and chloride of zinc, a well-known powerful antiseptic, is the substance which has been mostly employed for this purpose), serious consequences from wounds received in the dissecting-rooms have become almost unknown. In the thirteen years during which I taught anatomy in the University School, mainly before the war, lecturing each winter to large classes, I did not encounter a single instance of serious consequences following a wound received in dissection; and I attribute this result to the fact that all subjects used for dissection were carefully injected as soon as received, and always with chloride of zinc.

This degree of immunity, however, should not render us careless; for post-mortem examinations must often be made, and specimens of morbid anatomy handled, under circumstances where the precaution of previous injection is impossible.

It is remarked by most writers that bad cases fol-

lowed dissection wounds more frequently in former days, when uninjected subjects were used, toward the latter part of a winter's session of lectures, when the health was suffering from confinement and hard study. In fact, there are often causes in action in the case of the medical student, and also of the practicing physician, to temporarily lower the tone of the general health, which fully explain the occasional unhealthy behavior of otherwise trifling wounds without assuming the existence of a virulent poison; and yet there are cases in the past records of surgery of which the sudden and fatally overwhelming character can only be explained by the assumption that a virulent poison has been absorbed.

The late Dr. Hayward, an eminent surgeon of Boston, who has left a graphic description of his own case on record ("Remarks on Dissection Wounds," in "American Journal of the Medical Sciences," January, 1844, p. 64), expresses the opinion that a large share of the evil consequences attributed to wounds received in opening dead bodies is due to a bad condition of health from overwork or other causes, rendering the wounded party unable to resist injurious influences. This was his own condition, as he was more busy than usual in private practice, and in charge at the same time of a surgical service in the Massachusetts General Hospital. He pricked his forefinger slightly with a needle, and shortly afterward touched the surface of the intestine of a child, recently dead of tubercular meningitis, at a point of suspected ulceration. He was awakened at two o'clock the same night with pain of unusual intensity in the wounded finger, which gradually swelled, became livid in color, and within the week partially gangrenous; when laid open freely, not a drop of pus escaped. There were also symptoms of great general prostration, by which he was confined to the bed for a month.

It has been generally observed that the danger attending dissection wounds is greater when they occur

in manipulations of a recent cadaver than in handling a subject at a later period, after decomposition has really commenced. There are changes in the liquids and solids of the body taking place immediately after death, especially after death by certain diseases, which seem pre-eminently, in the opinion of many, to favor the generation of a virulent animal poison. These changes do not of necessity always occur, but they are very likely to be present where death has followed a surgical operation involving the peritonæum—as that for strangulated hernia, or where it has followed erysipelas, pyæmia, or puerperal fever. In fact, the very general agreement on this point among practical observers would seem to justify the inference that there is some noxious element or principle common to these last-named maladies which possesses an infectious quality, and is capable of producing similar poisonous symptoms. In the case of Sir James Paget, already referred to, the patient whose body he examined died, after the operation of lithotomy, with pericystitis and acute pleurisy, both of which it was suspected took their origin in pyæmia. Paget also states that he was overworked at the time of his exposure. He had at first pustules on the back of the hand, and then excessively tender axillary glands, followed by abscess of the back and side of the neck. Subsequently there was erysipelas of the trunk. The pus from one of his abscesses poisoned his nurse.

Lawrence gives the following case: "A lady, who had died of puerperal peritonitis, was examined, in the presence of a physician, at eight o'clock in the morning of December 28th. He assisted in sewing up the body, and was not aware that he had injured himself. At eight o'clock in the evening, being at a dinner party, he felt some heat and uneasiness at the end of a finger, and it occurred to him that he might have pricked it in sewing the body, though not aware of having done so. A slight blush was observed, and with a lens a minute

opening in the cuticle was perceived at the center of the red part. This was touched with nitrate of silver and with a minute quantity of nitric acid, without causing pain. He went home, and, finding the finger still uneasy, as the former applications had given no pain, he again applied nitrate of silver, continuing the application till he felt it sensibly. The pain thus produced soon increased to agony, and shivering came on. Red lines were observed on the hand at half-past eight on the following morning, and an eschar equal in size to a split pea had formed on the finger. Leeches, fomentations, and poultices, with purgatives, were now resorted to. At one o'clock P. M. the last two phalanges of the finger had mortified. The red lines now extended to the elbow, with uneasiness in the axilla. There was complete prostration of strength, irregularity of breathing, and torpor, and the pulse varied from 90 to 100, and was soft. During the rest of the day there was much heavy sleep, with intervals of pain. The hand and arm had swelled, and also the axillary glands. After this there was great torpor, with depression and oppressed breathing. An erysipelatous blush arose on the axilla and side of the chest. Death took place at six o'clock A. M. on January 1st—the fourth day." (Lawrence's "Lectures on Surgery," London, 1863, p. 276.)

In this typical case caustics were used with a degree of freedom amounting to officiousness, under the influence of the exaggerated ideas formerly held as to the virtues of nitrate of silver. Its entire uselessness, and also that of the other measures employed, is fairly demonstrated.

Godman, the American anatomist, records the case of young Kissam, of this city, whom he attended, with the late Valentine Mott, in 1827. Kissam, forty-eight hours before, with a fresh cut on his finger, had persisted in taking out the viscera of a recent and uninjected subject. Godman notes the altered expression

of the patient's countenance, and his rather unexcited pulse. He observed that the lymphatics of the chest along the border of the pectoralis major muscle of the wounded side were visibly inflamed, but there were none upon the arm. In this case death took place on the sixth day, with symptoms attributed by Godman, after post-mortem examination, to *violent acute gastro-enteritis*—very much the same as we should now ascribe to *acute general septicæmia*. ("American Journal of the Medical Sciences," 1827, p. 315.)

Travers, in his "Essay on Constitutional Irritation," gives the case of a student, which presents a still more rapidly fatal issue: He slightly punctured his finger, in opening the body of a hospital patient recently dead, at noon on Monday. Pain came on in the evening, and increased in the night, with high constitutional irritation. The next day, with slight redness of the puncture, according to Travers, "the nervous system became agitated in a most violent and alarming degree, the symptoms nearly resembling the universal agitation of hydrophobia." Death took place at three o'clock on Wednesday morning—that is, in less than forty hours.

Maurice Collis, a prominent Dublin surgeon, cut himself while performing an operation for the removal of a malignant tumor of the upper jaw. Collis died on the seventh day, with diffuse swelling on the front side of the chest, utter prostration and apathy, a high temperature, shiverings, some rusty expectoration and tubular breathing, and albuminous urine. He was already run down in health, and overworked. His symptoms are described as those of "diffuse cellular inflammation," complicated with pyæmia.

I have mentioned this case to show that in persons in broken health, where the vital powers are already depressed, the altered fluids, even of a living body, may act, apparently, as a virulent poison.

Finally, the case of the late Dr. Anstie, of London, who was about to take up his residence in New York,

shows the same typical features. "Some girls at a school had died of peritonitis," says Druitt (11th ed., p. 147), "a consequence of blood-poisoning by impure water." He performed a post-mortem examination on the sixth of September, 1874, and in so doing pricked his finger. On the eighth there was nothing to be seen about the wound, but he complained of pain in the arm and great lassitude. On the ninth there was greater pain and stiffness in the axilla, yet nothing was to be discovered about the arm. On the tenth the symptoms were aggravated, and there was intense and uncontrollable chilliness. On the eleventh there was a blush of erysipelatous redness over the right chest, with physical signs of rapidly advancing pleuro-pneumonia and wandering of the mind. On the twelfth, within the week, he died. Here there was general poisoning, with but little evidence of local irritation along the course of the lymphatic vessels by which the poison entered the system. The erysipelatous inflammation, not only of the external integument, but also of the serous membranes, is significant of blood-poisoning; and, when associated with deep suppuration beneath the thoracic muscles, the case presents a group of symptoms characteristic of the graver classes of dissection wounds. Their pathology, with some slight peculiarities—such as the grouping of symptoms just indicated—belongs to that of *pyæmia, septicæmia, and malignant erysipelas;* and in connection with these diseases we shall hereafter encounter all the features of its morbid anatomy.

The cases I have detailed comprise all that it is necessary to say at present concerning the symptoms attending dissection wounds. Their *diagnosis* turns upon the point as to whether there has been absorption of poison, and their *prognosis* upon the amount of poison absorbed and the ability of the organism to resist it and throw it off. *I have little doubt that many a harmless cut has been tortured into a serious sore by caus-*

tics and officious treatment, where little or no virus has been absorbed.

The condition as to health of the wounded party evidently plays an important part in determining both the nature and the gravity of the issue in this as in all instances of exposure to noxious influences. Of Mr. Erichsen's six students who were poisoned by the same subject, two had suppuration of the connective tissue under the pectoral muscles and in the axilla, one was seized with a kind of maniacal delirium, a fourth had typhoid fever, and the other two were seriously though not dangerously indisposed.

The *treatment* of dissection wounds is *preventive* even more than *curative.* We must avoid getting ourselves into the state of health in which the system becomes sensitive to these noxious influences and unable to throw them off. Crowded quarters and late hours are to be avoided; the selection of good food, regularity in habits, daily ventilation of the blood by exercise in the fresh air, and in the sunshine when feasible, cleanliness, and temperance, are to be strictly observed. Before exposing the hands they should be rubbed with vaseline and balsam of Peru, or carbolic acid. When a wound is received, of ever so slight a character, the part is to be promptly cleansed and subjected to suction by the mouth; when bleeding has ceased, good court-plaster is to be carefully applied and the part kept entirely at rest. I think the local use of caustics more likely to do harm than good. Paget says of his assistant in the case in which he himself was poisoned: "Mr. Young, who began the examination, cut himself and suffered no harm. He did what I would advise you to do in any similar case. He washed his hands, sucked the cut part, made it bleed freely, and then took care of himself, and did not rub the cut part with nitrate of silver."

If soreness be felt along the fore-arm, the limb should be placed in a sling, and, after a mild cathartic, quinine should be liberally administered. In the case

of Dr. Anstie, just mentioned, I have a conviction that, if he had been saturated with quinine during the two days before the first symptoms appeared, the result might have been different.

If pain continue, prolonged soaking, in warm carbolized water, of the hand and fore-arm for two or three hours at a time is an excellent measure, the quinine meanwhile being pushed to tolerance. If more serious symptoms follow, such as pain in the axilla and shoulder, with headache and nausea, and chills and shiverings, the general plan of treatment of septicæmia is to be adopted.

The principal remedies are quinine, alcohol, and opium. The latter is required in efficient doses, for the pain in this disease is often intolerable in character, and the influence of opium seems to protect and sustain the shattered nerve-force. Hayward found more relief from bathing the affected parts with laudanum, and from leeches, than from warm fomentations and poultices. He speaks highly of the effect of applying a blister around the arm, even after the inflamed lymphatics have extended to the axilla. I have reason to think well of the *actual cautery* applied, under the influence of ether, to the wound itself, and in a linear manner over the surface of the fore-arm, or arm—especially across any inflamed lymphatic trunks that may have made their appearance. This remedy is believed by Bonnet, of Lyons, and other good surgeons, to arrest the tendency to "diffuse inflammation," which means death of connective tissue, and thus to create a barrier to the farther extension of the local poisoning.

Where great tension of the integument occurs from infiltration and swelling of the connective tissue, I should advocate free and generous incisions, even *without reference to evacuation of pus*, for the purpose of arresting destruction of tissue; and, where an anæsthetic has been employed while making these incisions, I should also apply the cautery (Paquelin) freely at the

bottom of them, believing that this measure has power to circumscribe and localize the traveling "cellulitis," and to otherwise arouse the failing recuperative energies of the poisoned organism. Traveling cellulitis means actual or threatened death of "cellular," or connective tissue. Hayward said of his finger that, when it was laid open toward the end of the first week, not a drop of pus escaped, nor was there "anything about the part that looked like healthy inflammation"; and this is equally true, in their earlier stages, of the painful swellings so common in the axilla and under the *pectoralis* and *serratus* muscles. Early incisions into these swellings usually fail to discover pus. Pus forms when the case is about to take a favorable turn. *Before the formation of pus, which is significant of an effort at repair, there is simply tendency to death of connective tissue.* This tendency to death of connective tissue we shall meet with again in so-called phlegmonous erysipelas, a disease which has not a few features in common with the graver cases of dissection wounds.

After abscesses have formed, and the more immediate danger from septic intoxication has passed, there is another struggle for life in the effort to contend against the profuse suppuration and the slow repair that follow, requiring the best management in the way of supporting diet and remedies to bring about a favorable issue of the case.

The *mode of death* in fatal cases of corpse poisoning is not clearly indicated by any of the authorities I have quoted; nor is there any well-defined opinion expressed on this point. There seems to have been a general disinclination to make post-mortem examinations in these cases, even when occurring among medical men. The action of a virus is admitted by all. Pyæmia and erysipelas are spoken of, but vaguely, as probably often present. As to septicæmia, which of all causes of death would seem the most probable, the same uncertainty prevails. I should sum up the causes of death in this

affection as follows: First, the overwhelming efforts of a poison, properly called a septic virus, upon the nervous centers; second, the slower influence of the same virus upon the blood; and, third, death by exhaustion, in the subsequent effort to get rid of the local effects of the poison, in the way of sloughs, by suppuration, and the subsequent repair of the parts.

It is obvious that, in endeavoring to resist by treatment the tendencies to death, we find ourselves contending mainly against septicæmia.

In cases of recovery there is generally a more or less prolonged struggle against depressing influences. After a slow convalescence, the patient is often left with a deformed finger, a weakened arm, and not rarely with permanently damaged health.

After most poisoned wounds, of whatever kind, there are local evidences of impaired vitality which remain. Even a mosquito bite shows a tendency sometimes to leave a troublesome sore; a vaccine pustule may become irritable and slow in healing; and an objection has been raised against inoculating from chancroidal ulcers for the purpose of diagnosis on account of the danger of phagedenic complication. I have known poisoning by the bite of a centipede followed periodically for some years by an annual eruption in the original locality.

Among the poisoned wounds encountered in practice, those inflicted by venomous serpents are not the least frequent. Dr. Moore, of Mississippi ("American Journal of the Medical Sciences," 1827, p. 341), reports no less than seventeen cases of bites of moccasin and rattlesnakes as having occurred under his observation. These are the two poisonous snakes of which we hear most frequently; the copperhead is occasionally spoken of in Southern journals, but throughout the North the rattlesnake is our only poisonous reptile.

Of the seventeen cases of snake bite seen by one practitioner, fourteen are reported as having been "cured by the internal use of the volatile alkali am-

monia.'' Now, inasmuch as recent and entirely reliable experiments have demonstrated, according to Dr. Weir Mitchell, that ammonia, in no form, has any especial virtue as an antidote to serpent venom ("Researches on the Venom of the Rattlesnake," "Smithsonian Contributions to Knowledge," 1860), it may be inferred that these victims of snake bite, if left to themselves, would have got well by the unaided efforts of nature.

It would seem, then, that the bites of these reptiles are capable of causing death in but a small proportion of the cases bitten. Equally exaggerated ideas prevail in Europe as to the degree of danger from the bite of the viper, the only poisonous reptile found on that continent. The number of specifics proposed for its cure is ridiculously large, but none has succeeded in maintaining a reputation, because the fatal case due in the regular percentage of mortality inevitably comes in to spoil the record. This percentage for the viper bite is about five and a half in a hundred. In 362 authentic cases collected in certain departments in France by M. Viaud (Report, etc., in "Le progrès médical," September 4, 1875), sixty-three were fatal. Dr. Moore's seventeen cases, which included the bites of moccasins as well as of rattlesnakes, give about the same. Harlan, a well-known American naturalist and a good authority, estimates that "not one case in ten of rattlesnake bites would prove mortal if left to nature"; but his estimate is too low. Mitchell, the highest authority on this subject, says he has collected at least fifty reported cases, but of these only sixteen were sufficiently rich in details to be of value. Now, these are almost all American cases, for the *crotalus* is not found out of our country except in zoölogical collections; and this fact is not flattering to us as observers. Of these sixteen cases, four were fatal—i. e., twenty-five per cent.

The instance in which death followed the bite of a rattlesnake after the shortest recorded interval was

that of an English physician, resident in this city, in 1848, of whose case I was cognizant. He had received a large snake in a cage as a present from the South, and, while exhibiting it to some friends, exposed himself inadvertently, and was bitten on a finger. There was a small jet of blood from the wound, and immediate swelling followed, which advanced rapidly up the arm, involved the shoulder and the pectoral muscles, and was followed by livid discoloration. There was great prostration, with much excitement of manner. The pulse two hours after the bite was only 80, but it afterward rose to 120 and became more feeble. The patient gradually fell into a state of coma, *and died in five hours and a half.* The remedies employed were suction of the wound—after its incomplete excision within half an hour—ligature around the arm, and "carbonate of ammonia and brandy in as large doses as the patient could be made to swallow." But I am bound to tell you that the remedies were not used promptly, nor were they pushed. There was no post-mortem examination. (The case is reported by Professor A. C. Post, M. D., in the "Buffalo Medical Journal and Review," 1848, p. 115.)

In a fatal case reported by Professor W. E. Horner, of the University of Pennsylvania, the eminent anatomist, a drunken man was bitten at the elbow, and died in eighteen hours. There was, locally, itching, with great pain and swelling; a feeble pulse; vomiting, followed by a stool; a convulsion; and cold extremities. The mind subsequently became clear; death took place by failure of the heart. On examination of the body by Professor Horner, four hours after death, the blood was found everywhere fluid. The cortical substance of the brain—examined first—was intensely congested and of a deep-brown tint; the mucous membrane of the large intestines was also excessively congested, and that of the small intestines "dotted with patches of acute inflammation." It is worthy of note that it was upon similar appearances in the intestines that Godman based

his opinion of death by gastro-enteritis in the case of Kissam. The local swelling was due to serous infiltration.

In the *first* of these cases, where the party was bitten by a large, vigorous snake, which had been long confined, a large amount of venom was evidently injected into the tissues, and death followed promptly from its direct effects upon the brain and heart. In the *next* case the first effect of the poison—that upon the nervous centers—was survived, and the patient died later from its septic influence upon the blood, which was rendered "perfectly fluid" and unable to coagulate.

In a *third* fatal case, reported by Sir Everard Home, the patient survived both the nervous shock and the blood-poisoning until the seventeenth day, and he then failed through exhaustion in the attempt to throw off extensive local sloughs of skin and connective tissue at the seat of injury, as in phlegmonous erysipelas, or in certain phases of dissection wounds.

In fact, the modes of death in these cases of snake bite correspond very closely with those which I have lately described as taking place in fatal dissection wounds. This analogy in their poisonous effects leads to the inference that the putrid or septic poison derived from the dead body is allied in some way in its nature with serpent venom; so that whatever we can learn of the latter will possess a double interest for us.

The actual amount of venom injected has undoubtedly a direct influence upon the danger of a serpent bite. In the rattlesnake, the anatomical construction of its fangs and many other circumstances explain why the injection is so often imperfectly accomplished, and why so many victims escape fatal consequences. The quality of the venom is apparently always the same, but there is variety in the ways in which it is applied.*

* The strong interest manifested in septic poisons at the present time invests serpent venom with unusual importance. That of the rattlesnake is a typical poison of the class, and whatever we can learn concerning its

In favorable cases it is proved, by Mitchell's experiments and observations, that this fluid condition of the blood, when produced in man by serpent venom, can be, and is, recovered from.

Mitchell removed the contents of the poison-sac of a snake, and found that admixture with the venom caused at first no appreciable change in the coagulability of the blood ; but, by protracted contact, the fibrin of the blood lost its power to coagulate, and its putrefaction was distinctly hastened. According to Professor Brainerd, of Chicago, who also experimented on this subject, when an animal bitten dies soon, its blood is coagulable ; but when death is delayed it ceases to exhibit this quality. In one of Mitchell's dogs, exposed to be bitten by a healthy snake, blood drawn at intervals of a few hours showed less and less disposition to coagulate, and finally, at twenty-seven hours, refused entirely—remaining fluid. The dog was excessively prostrate, he bled at the gums, his eyes were injected, he vomited, had bloody stools with tenesmus, and refused food. *But he survived*, and on the fourth day his blood, on being tested, again coagulated feebly. Profuse suppuration afterward came on in the thigh, where he had been bitten, and the dog slowly and gradually got entirely well.

In analyzing his tabulated results of cases, Mitchell

intimate nature and mode of action may throw light upon human diseases caused by putrid poisoning. In all the recent discussions in the learned societies abroad on the phenomena of septic poisoning, I have met with but one allusion to the resemblance between them and the effects of serpent venom, and this was a passing remark by Gosselin, the veteran surgeon of La Charité. If the East Indian cobra or the American rattlesnake existed in Europe, we should probably hear more of the septic power of their venom. The fluid condition of the blood found by Professor Horner in his fatal case (which is the only post-mortem examination by an expert, after death by this poison, which I have been able to discover), and the intense congestion, in patches, of the stomach and bowels, bear a strong family resemblance to the appearances seen after death by putrid poisoning and septicæmia.

observes that "where the patient was several days or longer indisposed, the delay in recovery was usually due to the *local* lesions rather than to prolonged alteration of the blood."

We can thus understand how, if the dose of the venom received by the victim of a snake bite be insufficient to destroy life—either by its immediate effect upon the nervous centers or by its more chronic action upon the fibrin of the blood—after causing the most profound prostration and threatening the gravest results, its effects may presently pass away and disappear in the most sudden and complete manner; so that a patient who has been seen by his physician over-night apparently in the jaws of death, in fact given up to die, may ride over the next morning on horseback to announce his convalescence — as is stated in a recorded case.

This peculiarity of serpent poison seems to be common to all the venomous snakes: it is true of the viper, which is far inferior to the rattlesnake in its deadly quality; and of the cobra and its congeners, of India, which are still more deadly. The object with which serpents are endowed with this venomous power—that is, to disable the animals which constitute their prey—would seem to explain both the suddenness of action and the evanescent quality of the poison. The animals thus killed are safely eaten by man, as is proved by the statement of Sir James Fayrer, the great authority on the serpents of India. The chickens killed by the cobras, in his experiments with the vaunted native remedies, he found had been habitually eaten, contrary to his orders, by his native servants, and with entire impunity.

Thus it would seem that poisoning by serpent venom bears this much resemblance to poisoning by opium, namely, *that, if we can keep the heart beating* until the effect of the poison passes off, the patient may be saved.

This evanescent feature of serpent venom explains

also the individual reputation of the numerous "infallible" remedies for snake bites that are extant. When the patient recovers by the natural lapse or fading out of the poisonous impression, the cure is placed to the credit of the remedy employed, and thus its reputation is enhanced; but when the fourth case occurs—in which the dose of the poison has been efficient to kill—then the vaunted remedy proves powerless. Thus it has proved with iodine, recommended by the late Professor Brainerd, of Chicago; and with the compound of bromine, iodine, and corrosive sublimate, known as "Bibron's antidote"; and with ammonia.

Upon what remedies, then, in a case of snake bite can we rely? *Locally*, upon the prompt application of a ligature, when a limb is the part bitten, and immediate scarification of the wound and suction by means of a cupping glass when feasible, or, still better, by the mouth. *Generally*, upon alcohol—as the most available stimulus to the heart—introduced into the circulation fully and freely by every available avenue, keeping up the effect just short of intoxication; and also by keeping up the temperature of the body by artificial heat. A further word will be necessary as to each of these remedies.

The ligature, to be effective, must be applied very tightly, and, still better, several may be applied, at diferent points of a limb—tourniquets by preference, if at hand. Then, to avoid harm from their tendency to produce gangrene by stagnation, an opportunity should be early taken—as soon as the pulse has responded to the stimulus of the alcohol—to temporarily loosen and readjust first the ligature nearest the wound, and then the others. The too early and entire removal of the ligature from a limb has been actually followed by sudden and fatal collapse in a case that seemed to be doing well, proving at once the efficiency of the ligature in delaying the entrance of poisoned blood into the circulation, and demonstrating also the necessity of manage-

ment so as to permit it to enter only in installments, as it were, and as the pulse indicates that it may be done safely, so that the depressing effect of each installment may be tided over in detail by the aid of alcohol—thus constituting what Mitchell calls "the intermittent application of the ligature."

Excision, as usually effected, requires too much time, and might cause injurious loss of blood; moreover, absorption takes place too rapidly for excision, if ever so instantaneously done, to prevent it. The object of scarification is to facilitate free withdrawal of the poisoned blood from the seat of the wound.

Suction by the mouth is safe; the poison is innocuous, even if taken into the stomach. A recent wound of lips or mouth might possibly allow absorption to take place; but the quantity would be small, and the effects probably not serious. It would not be foolhardiness, therefore, for a surgeon to face so small a danger to possibly save a life. *There is no case on record of harm received in this way.*

The use of alcohol requires judgment: too largely given, it is capable of aggravating the excessive sedation caused by the poison. On the other hand, in bad cases of poisoning, as in the first instance I related, it is difficult, and sometimes impossible, to get the patient to swallow enough to overcome the deadly weakness of the heart's action. Under these circumstances, warm spirit and water should be injected by the bowel, and, as Mitchell recommends, the patient should be made to inhale the fumes of heated alcohol, or the vapor of ether. Alcohol diluted with water, one part to four, may be employed in subcutaneous injection. The intravenous injection of ammonia—the ordinary aqua ammoniæ diluted with an equal quantity of water—has been shown by Dr. Gaspar Griswold to stimulate the heart with remarkable promptness and certainty, even in the moribund. After many experiments on dogs he injected a drachm of this solution into a superficial vein

of the fore-arm in an apparently moribund woman after the operation of thoracentesis, with the effect of saving her life at the time, and more than a fortnight afterward the patient was doing well. ("Medical Record," June 7, 1879.)

In threatened death from rattlesnake poison the same rapid *depression of temperature* in the body takes place, as shown by the thermometer, which we noticed in *shock*, and which sometimes occurs in fatal septicæmia—a phenomenon demonstrated by Brown-Séquard as taking place under the influence of narcotic and other depressing poisonous agents. ("Experimental Researches Applied to Physiology and Pathology," New York, 1853, p. 26 *et seq.*) This teaches us to sustain the temperature of the body by heat applied artificially, as by bottles or caoutchouc bags of hot water, bags of scalded bran, heated sand, or ashes.

To sum up, finally, *the indications for treatment*—which consist, essentially, in recognizing and resisting the tendencies to death—serpent poison kills in three ways: First, by the brain, by direct sedation—for which the remedies are, constriction of a limb by ligation, scarification and suction, alcohol, and external heat; second, by disorganization of the blood—as manifested in its fluidity—a condition which will pass away in a limited time if the heart can be kept beating and the warmth of the body preserved; third, by subsequent local sloughing and suppuration, producing exhaustion. These are to be met by suitable incisions, stimulating dressings, and supporting general treatment.

CHAPTER XVI.

Septicæmia.

The general outline of symptoms and, in fatal cases, the mode of death, in the two examples of poisoned wounds we have been studying—i. e., dissection wounds and serpent poisoning—are suggestive of *strong similarity if not identity in nature of the noxious agent in the two affections.* The most prominent feature in the poison in either case is its power to promote putrefaction in the part to which it is directly applied, as in the tendency to gangrene in the wounded finger in one case, and the sloughing of the wound in the other. The next common feature is the power to infect the blood with a distinctly poisoned condition, causing obvious loss of vital quality in the elements of the blood itself, and death of the tissues to which it should afford nourishment. These qualities are expressed by the word *septic*, which is in such general use at the present day. According to Webster, *septic* means "having the power to promote putrefaction."

As long ago as 1815 the eminent French chemist, Orfila, recognized that putrid substances possessed poisonous properties, and demonstrated the fact by killing horses by injecting putrid animal matter into the venous circulation. Experiments on animals illustrating the effects of putrid poisoning have since been made very frequently, mainly with the design of finding out the essential nature of the poisonous element, of isolating it, if possible, and also of determining just how the poison produces its injurious effects and destroys life.

In these experimental researches, besides making it clear that there is a certain similarity in the symptoms preceding death in all cases of septic or putrid poisoning, *many collateral facts have been observed and established*—e. g., first, that the effects of the putrid poison are, in a general way, proportionate to the amount of the poisonous material injected—from the simple nausea and depression that follow a small dose to the speedy death caused by an overwhelming amount; second, it has been proved that the putrid poison may multiply itself in the body of an animal after injection, rendering its fluids and excretions also infectious; third, that the emunctories of the body tend to relieve the organism of the presence of the poison by carrying it off; fourth, that the lowering of temperature of the body, which is the first effect of the putrid poison, when not promptly fatal by its direct effect upon the nervous centers, is followed by an unnatural increase in the animal heat, and the phenomena of fever; fifth, that the changes in the poisoned blood favor the formation of obstructive plugs or emboli in the smaller vessels, provoking subsequent abscess formation to get rid of them; and, sixth, that the presence of the poison in a wound interferes with the process of repair.

You may gather, in a general way, from this brief statement, how great an interest belongs to these researches, and how much curative power is likely to result from the knowledge thus sought. Thus, if the drift of opinion now prevalent concerning what is called the antiseptic treatment of wounds, and which it is my object to present to you in judicial terms, shall become established, which, with possible slight modification, I consider more than probable, we shall have a satisfactory explanation of the cause of traumatic fever as well as of *the specific and infectious surgical fevers and inflammations.*

I have already told you that the best opinion on this point ascribes *the cause of ordinary traumatic fever*

to the entrance into the circulation from the wound of certain new combinations of animal matter resulting from disturbance of the vital processes in the wounded part. Billroth claims a *pyrogenic* or fever-producing power for this "new combination," as he styles it, but which we may now call septic poison. He assumes also that in another form it possesses an *inflammation-producing power*, and coins for it the new term of "phlogistic zymoid." In the case of traumatic fever the amount of poison absorbed may be very trifling, and in a healthy organism the blood may be promptly freed from it by the natural emunctories; or, under less favorable circumstances, grave symptoms of what is known as *acute general septicæmia*—which means overwhelming infection of the blood by septic poison—may follow.

Again, when blood changes have led to embolism and so-called metastatic abscesses, we have all the characteristic features which constitute what is called *pyæmia.*

Interference with the process of repair by the presence of the septic poison in a wound explains the train of unhealthy symptoms usually described by the obscure and often misused term inflammation.

Verneuil called this wound-poison "traumatic virus," and believes that it is begotten in the chemical and vital changes taking place in a wound in the interval between the moment of its infliction and the formation of an organized coating of plastic lymph, while vessels are still open to permit its absorption.

It is generally admitted that the most common avenue of entrance of septic poison into the blood is through the wound, and that its entrance through the lungs, although possible, is more rare. Also that septic poison may be either generated in the organism of the patient, or brought from without; in other words, there may be *auto-infection* or *hetero-infection.* Finally, it is held by Gosselin and many others that there are many varieties of septic poison.

And now if the question is asked, What have these researches and experiments determined as to the ultimate nature of the poison—the existence of which all admit—and as to the possibility of isolating it, I have a less positive answer to give. The learned world is divided at the present time in opinion, one party advocating the *chemico-vital theory—that septic poison results from decomposition and recomposition, under impaired or disturbed vitality, of the complex and unstable organic compounds of which the fluids and tissues of the body consist;* the other party upholding the *germ theory—that putrefactive changes and all their damaging consequences are due to the struggle for life of myriads of microscopic organisms of a low order of vegetable life, always present in the air we breathe, and which find favorable conditions for development in our bodies.*

The first party includes Robin; Billroth, of Vienna, with his "phlogistic zymoid"; Verneuil, of Paris, who advocated the formation of a "traumatic virus"; and Bergmann, who considers that he has isolated the poison sought for in a substance analogous to the alkaloids, morphia, and atropia, which he has named "*sepsin.*" These, or many of them, deny the agency of the low organisms or germs either entirely, or they admit it only in part, granting, like Billroth, that the germs may be carriers, but denying that they are originators of poison; or, like Burdon-Sanderson, asserting that although bacteria have nothing to do with the production of the fever-producing poison, yet that this poison can not be separated from bacteria unless "by boiling the material in alcohol, which kills the bacteria without destroying the fever-producing agent." ("Transactions Pathological Society," London, April 6, 1875.)

The germ theory has for its most prominent authority M. Pasteur, the French Academician, its reputed discoverer, with Tyndall and Lister as his supporters in England.

Pasteur, as you are probably aware, was employed by the French Government to investigate the causes of the silk-worm disease which was impoverishing France. After long and able research, he proved that the French race of silk-worms was for the most part degenerate, and hopelessly doomed to destruction by the invasion of a microscopic vegetable parasite which infested even its eggs. A remedy was found in the importation of healthy eggs from China and the founding of a new race; and this measure saved the French silk culture. During his investigations of the silk-worm disease, Pasteur avers that he discovered a species of microscopic vegetable organism which he calls *vibrio-septica*, from its pre-eminent power of provoking putrefaction, the *germs of which he found to be singularly indestructible.* They resisted prolonged boiling in absolute alcohol, and even retained life *in vacuo*, in pure carbonic-acid gas, and in compressed oxygen. They were found, moreover, to possess the power of proliferation *as germs, or imperfectly developed individuals*, a quality of partheno-genesis existing in some plants and insects —the honey-bee, for example. The parent vibrio was found to be killed by oxygen, but its corpuscular germ, as I have said, was almost indestructible, and proliferated, *as a germ*, without limit. Under favorable surroundings—i. e., away from oxygen—the corpuscular germ developed again into the parent *vibrio-septica*, and, in the struggle for life of this race of vibrios, putrefaction followed inevitably. The discovery of the double life of this vibrio, M. Pasteur avows, suggested to him the possibility of accounting for the origin and propagation of infectious and contagious diseases in man by its mode of proliferation. He formally announced his discovery, and his belief concerning it, to the French Academy in 1866. Mr. Lister, then a surgeon of Glasgow, but educated thoroughly as an expert in microscopy and experimental physiology, and previously familiar with Pasteur's investigations and views,

adopted his suggestion, and began at once to search for some means of controlling the exceptional viability and proliferative power of these septic germs, and of protecting surgical wounds from their invasion. His design and his hope was in this way to cut off the danger of inflammation and unhealthy complications, *the most common sources of interference with the normal process of repair.* He had been for some time experimenting with different devices for keeping floating air-germs out of open wounds, when he learned, rather accidentally, that a newly discovered substance, called carbolic acid, possessed remarkable power in destroying the germinating power of the lower organisms. This power of the new agent, which had already been praised for its remedial qualities by M. Déclat, of Paris, and *especially its volatile and diffusible quality*, seemed to suit his purpose; and it still maintains its place as the best antiseptic agent in surgical dressings. Mr. Lister's account of his first application of Pasteur's theory to the treatment of surgical diseases (compound fracture and abscess) first appeared in the London "Lancet" in 1867.

In forming a personal judgment as to the comparative merits of the two theories just described, and pending the ultimate verdict of science, I have been led to adopt Mr. Lister's practice of antiseptic treatment from a feeling of duty, influenced mainly by what I have witnessed of its good effects.

Pasteur's theory as to the mode of septic poisoning, as applied to the prevention and treatment of surgical diseases and injuries by Lister, promises more benefit to humanity, on rational grounds, than the chemico-vital theory, which has thus far suggested no direct or certain remedy; and the germ theory has certainly carried promise to a certain degree of performance.

I would remark that it is not imperative to admit the theory in order to carry out the practice of Listerism; but, to do the latter honestly and to command the largest degree of success attainable, you must act as

though you believed it, and in no half-way manner. The strongest reason for regarding the germ theory of Pasteur with favor is the steady, growing, and acknowledged success which has followed Mr. Lister's treatment of wounds and surgical diseases as he has carried it out in accordance with this theory, with unwavering fidelity to his theoretical opinions, for nearly fifteen years.

But in this matter I have no desire to influence you to *partisanship, which in matters of science is always to be avoided.* I feel bound, therefore, to state, on the other hand, that the best argument within my knowledge in favor of the other theory—the chemico-vital—is derived from the singular qualities of the rattlesnake venom. As this is a poison, apparently, of purely chemico-vital origin, some details concerning it may prove of interest in this connection. The venom, as ejected by the snake, is a translucent, brownish-colored liquid of sirupy consistence, and, according to Mitchell, entirely destitute of microscopic or figured elements. In this latter statement lies the point of interest. The venom is the secretion of a gland lodged in a fossa of the jaw-bone, and accumulates in a reservoir or pouch communicating with the hollow fang through which it is ejected under muscular compression when the reptile bites. Mitchell says: "It is difficult to conceive of the singular energy of the venom of the rattlesnake without carefully conducted experimental research, or of the tenacity with which its powers are preserved in the presence of violent chemical reagents and extremes of heat and cold. The dried venom retained its potency after two years of climatic changes; nor was it in any degree impaired by strong sulphuric or muriatic acid, ammonia, chlorine-water, soda, or potassa. Iodine and tannic acid seemed to prevent its local, but not its constitutional symptoms. Freezing did not alter the powers of the venom, and the most prolonged boiling was inadequate to destroy its deadly qualities." (*Op. cit.*, p. 44 *et seq.*)

As to these deadly qualities, we have evidence from the same source: in an experiment an active frog was exposed to be bitten. In two hours after the usual symptoms of rattlesnake poisoning it was dead. "In twenty-four hours the muscular parts about the bite were almost semi-fluid from decomposition, while the rest of the frog had no odor or any other sign of putrefaction." (*Op. cit.*, p. 56.) He says: "The final influence of the venom upon the muscular structure was extremely curious." In every instance it became softened in proportion to the length of time the venom remained in contact with it, so that, after even a few hours in warm-blooded animals, and rather a longer time in the frog, "the wounded muscle became almost diffluent and assumed a dark color and somewhat jelly-like appearance. The structure remained entire until it was pressed upon or stretched, when it lost all regularity and offered the appearance under the microscope of a minutely granular mass dotted with larger granules."

There are certain diseases with which we have to contend which are undoubtedly produced by the introduction of a poison into the blood. Among these may be mentioned as indisputable examples *small-pox; large-pox, or syphilis; splenic fever, or carbuncular anthrax; and hydrophobia.*

Whether poisons of this class have their origin in chemico-vital action taking place in animal fluids and solids, as is the case, apparently, in the serpent venom, or in the introduction into our fluids and tissues of the germs of microscopic fungi floating as dust in the air, which generate with such marvelous rapidity when they find themselves in a congenial soil, is a question which science has not yet fully answered. I confess to a belief, meanwhile, *that there are many of these poisons, and that they may originate in both ways.* The snake poison is certainly a typical example, acting, as we have seen, even more promptly than the most

deadly corpse poison, and producing death in a strikingly similar manner. Its claim to the title of a *septic* poison is certainly demonstrable.

Here is another example from an experiment in the laboratory: Some blood was drawn from a healthy dog, who was then exposed to be bitten by a vigorous rattlesnake. In about thirty-five minutes the dog was dead. At the end of twenty-four hours the blood drawn before the dog was bitten was found as yet unaltered, and it had no unpleasant odor, but the blood in the dog's heart "was already unpleasant in smell, and that from the wound was quite putrid."

You have here an illustration of the effects of a *septic* or putrefaction-producing poison from a native reptile, observed by an American authority of the highest character. When the poison gland and pouch were removed from the animal and carefully washed, no poisonous quality whatever remained. The reptile's blood and tissues are entirely innocent of poisonous qualities. *The venom is, therefore, made or secreted out of normal non-poisonous blood by healthy glandular epithelium. Unless the "corpuscular germs" of the vibrio-septica have escaped unnoticed in this typical septic poison, these observations furnish a proof of its chemico-vital origin.*

The careful re-examination of the rattlesnake venom in this point of view might yield interesting results.

In this connection I think it will be profitable to learn what we can, in the next place, of the disease usually called *septicæmia*, to which I have already several times alluded.

Like other affections due to this mysterious source of blood-poisoning, the symptoms and characteristics of septicæmia in man, having come under general observation, comparatively speaking, only recently, are more or less obscure and mixed, in the minds of most practitioners, with those of more familiar diseases; so

that it is not an easy task to glean a clear description of septicæmia from the clinical records of others, nor yet to detail its features entirely from personal observation. At present almost every practitioner of experience has his own peculiar views of the subject. I will strive to give you a typical outline of the affection, which may serve as a basis for reference.

The name septicæmia was proposed by Piorry, of Paris, as late as 1847, the period at which the possibility of the existence of this affection first began to be generally recognized. By this term septicæmia "is understood the effects which are produced by the presence of putrid matter in the circulating blood."*

The clinical phenomena of septicæmia, as observed in man, are characterized not only by pyrexia, but also by vomiting, diarrhœa, muscular enfeeblement affecting particularly the heart and respiratory muscles, and ultimately by a condition of collapse which tends to terminate in death.

After death the blood is found to be darker and less firmly coagulated than usual. Extreme congestions and ecchymoses are met with in internal organs, especially in the heart, lungs, and gastro-intestinal mucous membrane. The spleen, liver, and other viscera are enlarged, friable, and abnormally vascular, and little patches of lymph are seen on the pleura and pericardium. Metastatic abscesses and all other secondary inflammatory lesions are completely absent.

Such pure, uncomplicated cases of septicæmia are, however, comparatively infrequent, the septicæmia being usually associated with the development of secondary suppurative inflammations, constituting what is known as *pyæmia.* A simple septicæmia is perhaps most common in the puerperal state—originating in auto-infection from putrid matter in the womb after childbirth.

It is important that you should grasp clearly the

* Green, *ut supra*, p. 99.

idea that is held by most observers at the present time, that *the condition called pyæmia "is the result of the development and absorption of the same poison as that which gives rise to septicæmia."* The two conditions are asserted by the latest English authority in pathology —who represents the opinions of Burdon-Sanderson—to be "*closely allied, and to be very often associated.*" . . . "Pyæmia differs from septicæmia in this respect: that in it the absorption and dissemination of the infective poison gives rise not only to an alteration in the blood and a general disturbance of the vital functions, but also to the production of secondary foci of inflammation — the so-called 'metastatic abscesses'—in the lungs and elsewhere, which I have already spoken of as resulting from thrombosis and embolism. The tendency to the formation of these obstructive plugs in the blood when altered by putrid poison has already been noted. It is the production of these abscesses, and of other more diffused inflammatory lesions, accompanied always by suppuration, which is the distinctive character of pyæmia." A prominent French surgeon and pathologist is recently reported as having stated as his opinion that "pyæmia is septicæmia, *plus* the disseminated abscesses." Or, as the English authority (Green, *ut supra*, p. 204) expresses it, "*it is probable that pyæmia is invariably associated with more or less septicæmia, and it may be regarded as a septicæmia in which there are metastatic suppurative inflammations.*"

Thus the three surgical fevers—the simple traumatic fever that follows most injuries and passes off harmlessly within the week; the more grave pyrexia that we now recognize as septicæmia, arising from a larger or stronger dose of the same poison, and more or less dangerous to life according to the extent of the dose, and the power of resistance of the patient; and, finally, the almost certainly fatal chills, sweats, and low fever of pyæmia, with its inevitable multiple ab-

scesses of the viscera—constitute, according to modern pathology, three degrees of septic poisoning, and each may pass into the other by almost imperceptible gradation. After our present study is completed, I will point out the more distinctive features of pyæmia.

To get a clear perception of the group of phenomena caused by septic poisoning in man, and of the anatomical lesions which result from its fatal action, I think it better that we should recur, in the first place, to the results of the experiments on animals in which putrid matters have been injected directly into the blood by opening a vein. Here there is no obscurity as to the source, and very little as to the nature, of the poison injected, and it is certain that it goes at once into the blood; so that the symptoms of poisoning that follow are fairly attributable to the presence of septic poison in the blood, and its effects upon the vital functions and living tissues of the body—in other words, they are certainly symptoms of septicæmia. Afterward we shall be better prepared to study the disease in man.

The results of these experiments upon the lower animals have been singularly uniform. Perhaps those of Bergmann in Germany, and Burdon-Sanderson in England, will best suit our purpose as condensed from a recent report by the latter: After the injection of from fifty to one hundred minims of putrid blood, carefully filtered, into the venous system of a large dog, the animal dies in from four to ten hours, death being preceded by *collapse, with vomiting and diarrhœa.* In guinea-pigs, collapse comes on very rapidly after injection. It is marked chiefly by loss of muscular power and *diminution of temperature.* In the dog or cat the phenomena are more marked. In some few cases the animal passes rapidly into the state of collapse, but more commonly an hour or two elapses before any striking effect is observable. Among the earliest obvious phenomena are muscular twitchings and shiverings, which may come on during the second or third hour.

Thermometric measurements in the rectum show that the temperature rises, from the first, until the supervention of collapse; this collapse, as I have just said, is marked by failure of muscular power, and accompanied by retching and vomiting, which are soon followed by diarrhœa. The diarrhœa is at first attended by tenesmus, but it afterward becomes colliquative. The stools are mucous, shreddy, and always more or less stained with altered blood. A few hours before death the temperature begins to sink, and it eventually falls below the normal standard.

The post-mortem changes correspond with the symptoms. "On dissection," says Bergmann, "the most important appearances are those found in the intestinal canal—e. g., intense redness and swelling of the mucous membrane. This alteration does not extend to the whole intestine, but affects the pyloric end of the stomach, the duodenum, the upper coils of the jejunum, the colon, and the rectum." "The intestine is filled with reddish, thick mucus which strikingly resembles the rose-colored rice-water of the cholera stool. The discharges contain shreds of epithelium." Bergmann did not notice peritonitis in his dogs.

Burdon-Sanderson says: "The peritonæum was always hyperæmic in the most severe cases, and hæmorrhagic spots were almost always present, particularly on the omentum and mesentery." This is the only point of difference between them.

Here we have a distinct view of the effects of a poison which tends to extinguish life by its direct action upon the nervous centers, and causes violent inflammation of the intestinal mucous membrane by provoking futile efforts at elimination. This constitutes the gastro-enteritis of which, according to Godman, young Kissam died after his dissecting wound. The tendency to hyperæmia of the serous membranes, and to hæmorrhagic spots of extravasation, or petechiæ, indicates profound alteration of the blood plasma.

In man the invasion of *general septicæmia* is marked by utter prostration, attended by apathy and torpor; the intelligence is unimpaired, except in activity, and there is little complaint of pain. The tongue becomes speedily dry, rendering the speech indistinct, and the patient is always ready to drink. The skin is also dry, and, as a rule, the urine is concentrated. Diarrhœa is common, the dejections being liquid, offensive, and tending to become colliquative; later in the case they are passed involuntarily. The temperature at first rises rapidly to 104°, 105°, or even higher, *but there are no rigors or chills, as in pyæmia*, save, exceptionally, at the commencement; and the thermometer shows a decreasing temperature as early often as the fourth or fifth day. This falling of the thermometer must not be taken as evidence of amendment, for it is significant of the final collapse in which life terminates —and this takes place generally within the first ten days. The pulse is that of typhus—feeble from the first, and growing more frequent and smaller, until some time before the end it becomes imperceptible, and, coincidently, the thermometer not infrequently falls considerably below the natural standard. The countenance is pallid, shrunken, and anxious in expression.

Although the mind is usually clear, the disease, according to Billroth, sometimes sets in with furious delirium. Profuse and offensive sweats occur in some cases, as though the system were making an effort to eliminate the poison through the skin.

In a lady whom I saw in consultation on the sixth day of the disease, twenty-four hours before her death, I was struck with the singular keenness of perception and acuteness of mind she manifested in inquiries as to her chances of life, and in speaking of the future of her children. In this case there was a question as to whether her disease had been the result of auto-infection from matters retained in aborting, or if it had been communicated, in his manipulations, by her

attendant. *Puerperal fever was prevalent at the time.*

On the whole, this appalling disease is marked from the beginning by a profound depression of the powers of life, as though a poison were exerting its influence directly upon the nerve-centers. Death from acute septicæmia may and does frequently occur more rapidly than I have indicated where an injury of grave character, for example, has caused collapse from which full reaction never perhaps takes place, the septicæmic poisoning being insensibly superadded to the collapse, and gradually extinguishing life. Perhaps, again, if reaction has justified such a course, amputation of a crushed limb may have been undertaken, and a return of the collapse, thus provoked, may possibly merge into septicæmic exhaustion and fatal sinking.

The morbid anatomy of septicæmia in many points differs little from typhus and other low forms of fever. The changes found in the intestinal canal are the same that occur in all fatal cases of septic poisoning. The gorged and softened condition of the spleen, lungs, liver, and muscular tissue results from the excessive temperature which the blood attains in diseases of this class. The absence of multiple abscesses in the lungs and elsewhere is noticeable, especially in rapid cases where septic embolism may not as yet have provoked suppuration.

Acute general septicæmia, as I have described it, is generally fatal; but the disease occurs in a milder form, characterized by less marked prostration, from which the patient in most cases rallies. In these cases the poison has not apparently entered the blood in sufficient quantity to overwhelm the nervous centers, and it is eliminated by the emunctories. In fact, *mild septicæmia exists after injuries and surgical operations more frequently, I suspect, than is generally supposed.* How always to recognize it is not easy to tell you in few words, for, as you have no doubt observed, this par-

ticular condition of poisoned blood is not stamped by any characteristic and well-marked symptoms like the chills and sweats which characterize so clearly a sudden invasion of pyæmia.

When a patient, after injury or operation, ceases, without any obvious cause, to do well, the granulations of his wound not looking quite healthy and having a little too much inflammatory redness and soreness lingering around it, with general depression and inappetence, a tongue tending to dryness, and a pulse which keeps too frequent—*if there is no hectic periodicity about the symptoms*, he may be fairly regarded as under the influence of *mild septicæmia.* Such a patient should be moderately stimulated, the secretions from his skin, bowels, and kidneys gently promoted, and his lungs supplied with an abundance of fresh, pure air, so as to secure thorough ventilation of the blood as well as elimination of poison by these emunctories.

This latter statement constitutes, in fact, the basis of treatment in all forms of septic poisoning. The *therapeutics* of septicæmia includes all the means at our command to free the blood from poisonous impurities, and to renew its elements by stimulating the process of nutrition. To meet the first necessity, an ample supply of air is an indispensable necessity, for sulphureted hydrogen is always present in the blood as a result of the decomposition provoked by the septic poison. Bernard's experiment demonstrates that this is promptly and readily eliminated by the lungs unless the air supply be restricted and the patient be compelled to breathe the same impure air over and over again. See, therefore, that your patients' supply of fresh, pure air is unlimited, *for it is as important as food, and certainly more important than medicine.* If the dicta of Pasteur are to be accepted, we should cause our septicæmic patients to inhale oxygen liberally and systematically, for he found that the vibrio-septica was always killed by this gas. It is a logical remedy, and certainly a

harmless one. *Alcohol* is a remedy of value, for it masks the nervous centers, as it were, from the directly mortal influence of the poison, and stimulates the nerve-force for the moment as well as the heart, while at the same time it resists the tendency to mental depression, and it also, in a certain degree, serves as food. Quinine in the form of bisulphate should be given steadily in liberal but not excessive doses. The theory of the therapeutics of septicæmia is, that, if the organism can be tided over the influence of the poison which has been poured into the blood, this may not have been necessarily fatal in amount, the supply of it possibly may not be renewed, successful elimination may be accomplished, and life thus saved. Hence the value of alcohol as a remedy suited to an emergency. The analogy with the mode of treating poisoning by serpent venom is very close.

The soda and potash salts are useful in renewal of the blood, also as eliminators by the bowels and kidneys, and, largely diluted, for bathing the skin. Thus I would recommend Rochelle salts, or phosphate of soda, where a laxative is required; the citrate of potass, or iodide of sodium, as a diuretic; and pearlash, or carbonate of ammonia and spirits, for local bathing. For diet, milk as liberally as it can be borne, with the addition of lime-water and gelatine to facilitate its digestion by preventing too great hardness of the clot, and some good spirit; gruels of farina, or oatmeal, with the addition of wine and sugar; bread.

Eggs and preparations of beef, etc., are better suited to exhaustive diseases which tend to assume a chronic character—which septicæmia does not. Moreover, when these articles of food fail to digest under the influence of the waning life-force, they add to the mass of the putrefactive material; caution, therefore, must be observed in their employment. In this view, salicine, glycerine, and quinine all tend to prevent fermentation in the stomach, and thus to aid digestion, beside their value

in other respects. The value of quinine in preventing fatal rise in temperature is great. Opium may be required to restrain diarrhœa if a diet of boiled rice with large doses of bismuth fail. A decoction of roasted rice with a little coffee is a good tisane; and tea and coca are both serviceable. Deodorizers should be employed in all possible ways; of these, the permanganate of potass is the most unexceptionable. Where there is a wound or a cavity, as of an abscess, it should be washed, as freely as safety from poisoning permit, with solutions of carbolic acid.

It remains for us to consider the *preventive treatment of septicæmia.* It is plain that we have no reliable remedy for the disease when fully developed; under these circumstances we are forced to face the issue as we may, "on general principles," and are compelled to speak of the disease when serious in type as generally fatal in its termination. Prevention, therefore, is the end to be mainly kept in view by the scientific surgeon. We are to use all the knowledge we can get as to the nature and habits of the malady, and turn it to the account of prevention. Septicæmia has not been described, to my knowledge, as occurring in the woods, except in connection with that peculiar epidemic of erysipelas that ravaged our country twenty-five years ago under the popular name of "black tongue." Country air may be regarded in a general way as antagonistic to septic poisoning. Dr. William Marcet, in a recent volume of the St. George's Hospital Reports, advocates the idea that septicæmia is a not infrequent cause of death through the poisonous influence of putrescent matter that originates in the body, when weakened by disease, by a sort of molecular decomposition through failure of the nutritive act. He regards certain modes of death in consumption as septicæmic, and asserts that there is a means of arresting this septicæmic tendency which "certainly acts very positively in bringing about the desired effect; this is removal to a high locality, some-

where on the hills, at a station between three and five hundred feet higher than that where the patient is residing." Cases are mentioned confirming this statement. Here, then, is evidence of another resource which is seemingly capable of antagonizing the tendency to auto-infection by septic poison.

A middle-aged man of full habit, from over-use of stimulating drink and food, is much more likely to get acute septicæmia after a compound fracture or an amputation than a thin, spare man of abstemious habits. Experience of this kind has no doubt led to the fashion of dieting patients in order to prepare them for operations—which, as a rule, is not wise, for the subject of an injury may be fat and at the same time robust and hearty, or he may be of spare habit and unhealthy.

We have seen that it is more common to meet with local as well as general septicæmic poisoning after contusions, crushings, and lacerations, where decomposing tissues remain in contact with living parts and virulent substances are liable to be generated and absorbed before granulations can organize themselves; *and that the deadly influence of these virulent substances is competent even to prevent the formation of a granulating surface.* Facts of this nature teach us that it is often wiser to remove injured parts where their recovery is doubtful; that free incisions are of great service to prevent stagnation of decomposing fluids in contact with living parts; that depending openings and artificial channels are often indispensable to allow pus to drain away as it forms rather than to collect and undergo decomposition.

We have also learned to avoid heavy dressings for wounds, which serve to retain discharges. Some even advocate leaving wounds entirely exposed to the air, finding a greater degree of success in the absence of all dressing. There is an argument for this in Pasteur's demonstration that the vibrio-septica is killed by oxygen; but frequent ablution with carbolic acid is nec-

essary. Scrupulous cleanliness in the material and manner of dressing wounds, the isolation of patients, the provision of generous air space and free ventilation, and the more liberal use of food and stimulants, are measures of great value in warding off not only septicæmia, but the other low infectious forms of disease which follow surgical injuries—such as erysipelas and hospital gangrene, which are now recognized as taking their origin often in septicæmia.

But of all preventive measures, the use of the antiseptic methods of treating wounds, which we may for convenience speak of as Listerism, seems to me really most worthy of this designation. As the wound is believed to be the main avenue by which septic poison enters the system, this novel method of antiseptic dressings proposes to accomplish both local and general protection against septicæmia; and it has to a certain extent secured evidence of success. In March, 1879, at the Surgical Society of Paris, M. Trélat, one of its most prominent members, applied to the advocates of Listerism the following remarkable language: "By their dressings and infinite precautions against septicæmia, since the prevalence of the new doctrines, we have witnessed the absolute disappearance of pyæmia from the surgical wards." When we add this testimony from a Parisian hospital surgeon to the evidence of the German surgeons, and especially of Volkmann, as to the disappearance of hospital gangrene from his wards since his adoption of Listerism, it would seem that duty to our patients becomes imperative to afford them the benefit of this practice. The additional trouble it imposes is only an apparent objection, for in the aggregate the number of dressings is lessened.

There is a final preventive of general septicæmia where a limb is profoundly involved in injury, and this is early amputation. Many years ago Chassaignac ("Thèse de concours," 1850) expressed the opinion, which few hospital surgeons of experience will dispute,

that a very severe traumatism is capable of almost instantaneously giving rise to the condition of putrid poisoning, just as perfectly as though putrid matter had been injected into the blood. He speaks of the prodigiously rapid cadaveric decomposition that follows certain traumatic lesions of overwhelming severity, and quotes six cases of complicated fractures in which death followed promptly "with typhoid symptoms and the marks assigned to septicæmia." I have already mentioned this source of danger as one of the principal considerations justifying primary amputation. In regard to this unwelcome alternative we can not be too well provided with reasons, for it is a measure which is often declined through ignorance of its absolute necessity.

CHAPTER XVII.

Pyæmia.

I SHALL ask your attention in the next place to some of the more common and characteristic features of *pyæmia.* The views held at the present day regarding the pathology of this disease simplify our task in its study. Septic poison, having gained access to the blood, begets, among other profound changes, a tendency to disintegration in the coagula resulting from inflammatory stasis or from other causes; and, in consequence of this disintegration, fragments of solid material are thrown off into the torrent of the circulation. These, lodging ultimately in the minute blood-vessels, generally of the viscera, and most frequently of the lungs, form *emboli*, or *plugs*, and give rise to a series of changes in the local circulation which culminate in small multiple abscesses. The altered blood also favors suppurative inflammation in the joints by interfering with the nutrition of the articular cartilages, probably through embolic obstruction of the blood-vessels through which they derive their nutritive supply. The pericardium, the larger serous membranes, and the connective tissue, are also the seat of inflammatory changes. In this way an amount of textural destruction results which is almost invariably destructive to life. You have here, then, in a few words, an outline of the pathology of pyæmia, septicæmia, embolism, and consequent pus formation.

These phenomena rarely, if ever, occur except where a granulating surface exists somewhere in the

body, communicating directly or indirectly with the external air. In connection with this point, as to the possibility of pyæmia without a pre-existing open sore, a case mentioned by Dr. Wilks, of London, always recurs to me: A young lady died after a week's illness with repeated chills and sweats, a haggard aspect, sunken eyes, delirium, and utter exhaustion. The case presented the characteristic features of pyæmia, but there was no wound or suppuration in which the blood-poisoning could have taken its origin. When, at the autopsy, a number of small abscesses were found in the lungs, the diagnosis became so certain that an exhaustive examination was undertaken of the other organs, in search for the starting-point of the pyæmic poisoning, and finally one of the Fallopian tubes was found distended with pus: a Graafian vesicle, after a menstrual effort, had lodged in passing through the tube, and had died; and pus had formed for the purpose of floating it out. ("Report on Pyæmia and some Allied Affections," by Samuel Wilks, M. D., "Guy's Hospital Reports," third series, vol. vii.)

The *symptoms* which characterize an invasion of pyæmia are as follows: Whether the injury be trifling and the wound healing kindly, or more severe with febrile disturbance still lingering, in from two to five days to as many weeks after the injury or operation, a chill, with rapid rise of the temperature of the body, occurs suddenly, and, as a rule, without any warning. Closely following the chill, more or less nausea, purging, or other evidence of intestinal disturbance, with fever and profuse sweating. Coincidently the wound ceases to furnish healthy purulent discharge; it puts on an altered appearance, and the aspect of the patient indicates depression and anxiety. In a day or two, the pulse usually retaining its increased frequency, there is a repetition of the chill, followed by a drenching perspiration; or, possibly, sweats may occur without any chill, and these may be repeated at irregular intervals.

Meanwhile the fever assumes a continuous form and a low type, and the patient becomes more anxious and depressed; he is restless, sleepless, wandering in his mind; develops a cough and pains about the chest; becomes yellow and pinched in expression; emaciates rapidly; complains of acute pain in a joint, or in several joints, and perhaps surface abscesses make their appearance. He becomes steadily weaker and more delirious, and finally, receiving little or no benefit from remedies, however assiduously and skillfully applied, he dies from exhaustion in from ten days to three weeks.

This is an outline of the symptoms of the disease which, under the names of "purulent infection" (first employed by Ambrose Paré), "purulent absorption," or "suppurative phlebitis," has been for so many generations the especial dread of surgeons, because it has so constantly interfered with the favorable result of otherwise promising wounds and operations. More recently it has been called "suppurative fever" and "surgical typhus." The name "pyæmia," although it involves an erroneous idea, which is now universally recognized, has come into such general use that, with this protest against its false meaning, it is better to continue to employ it.

Let us for a moment analyze its principal symptoms. The chill by which pyæmia is ushered in differs from other chills in no respect save that it occurs coincidently with the formation of a focus of suppuration somewhere in the organism, and that the temperature of the blood is exceptionally high. *The thermometer is of great use in determining the significance of a chill. The irregularity in the recurrence of the chills and the profuse sweating that accompanies them* are, in conjunction with the high temperature, the symptoms of greatest diagnostic value; and these, with the *pinched and sunken aspect* of the countenance, the *yellow tint* of the skin, the *utter*

prostration of strength and dejection of spirits which succeed, constitute a group of symptoms which may be regarded as pathognomonic of pyæmia.

The *yellowness of the skin* occurs very early, and seems to be a true jaundice, for the conjunctiva is affected, the altered blood having apparently at once disordered the hepatic function. The "sweetish," purulent, hay-like odor of the breath, although often very noticeable, is not always present.

The pulse in this disease is characterized by *frequency, lack of force, and variability;* the change in the quality of the blood is such that it fails to adequately stimulate the heart, so that *lack of frequency in the pulse early in the disease is no evidence of absence of danger.*

Although, as a rule, in an invasion of acute pyæmia, the wound becomes dry, the granulations shriveled, and the discharge from it serous and unhealthy, yet there are exceptions to this rule.

I have used the term "acute pyæmia," but in regard to *duration* the disease is notoriously uncertain. If I say that a large majority of well-marked cases terminate fatally during the second week, I must add, also, that exceptions to this rule are so frequent as to render prognosis in this respect unsafe. In the language of Paget, "the absence of nearly all respect to time is indeed one of the many characters in which pyæmia differs from most marked specific diseases. An invasion of pyæmia in the acute form may be followed in the second week by lapse into a chronic condition, which may not terminate for a month, or even two months, or which may even end in recovery."

Symptoms affecting the joints are exceedingly variable and uncertain: sometimes a joint will be exquisitely sensitive, as in acute rheumatism, and require an opiate; and again it will fill up with pus and excite so little attention that the discovery of the condition of the articulation is accidental. Thus, as in regard to its duration,

this curious disease shows as little respect to definite order and rule as to the age or sex of its victims, and as to its symptoms and prognosis. As Paget says, "it sometimes ravages the viscera rapidly, while in other instances it seems to smolder in the blood and to cause death by gradual prostration of the vital energies. It may leave marks of its invasion in a single organ or in several viscera, or expend its force on the limbs; and, while occasionally defying all efforts at prevention, seldom even giving any warning of its approach, it will at once convert a case which just before seemed full of promise into one past all hope of recovery."

It must be obvious to you, even from this scanty description, that we are studying a disease of peculiar and strongly marked features and of deadly power.

Unhappily, our means of cure, when it is once declared, are utterly inefficient. Preventive measures, therefore, demand attention as our most hopeful resource.

The assumed identity of this disease with septicæmia brings to our aid at once all the so-called antiseptic means of averting danger; and we have good evidence, from hospital surgeons abroad, that their use has already, in certain hospitals, notably diminished the frequency of pyæmia. It is no matter of surprise that the antiseptic treatment of wounds constitutes a rational and specific preventive of a well-marked specific disease which takes its origin in open wounds. It is natural that evidence of the efficiency of antiseptics should come to us first from the older hospitals of Europe, in which pyæmia and the allied diseases, erysipelas and hospital gangrene, have habitually prevailed to an extent to which we can with difficulty give credit.

Throughout our country, except in the hospitals of our larger cities, pyæmia has not been a common disease, because the influences by which it is most fre-

quently invited, especially overcrowding, have been wanting; and yet it is certain to occur from time to time, and in most instances when least expected. I have met with it in the apparently well-appointed dwellings of the rich, and have recognized no modification of its distinctive features.

A gentleman of sixty, for whom I had opened the bladder above the pubes for an impassable prostatic obstruction some months before, keeping a fistulous communication with the bladder permanently open, was seized with pyæmia, and died in ten days after his first chill. His shoulder-joint contained pus. In fact, I have recently seen a well-marked case in consultation, in which the disease came on a fortnight after a well-managed and successful operation for internal hæmorrhoids, and proved mortal.

It is only within twenty years that the influence of crowding surgical cases of disease together with an insufficient air supply has been fully recognized as a very potent cause of both pyæmia and erysipelas—in other words, of diseases due to blood-poisoning. The experience of our late war—during which hospitals were constructed on a new model, under the auspices of the Sanitary Commission, and measures employed to prevent overcrowding—proved that *these diseases were preventable in an obvious degree.* Mr. Erichsen, in his work on "Hospitalism and the Causes of Death after Operations" (London, 1874), uses the following language: "It would appear, in fact, that the air of a hospital ward is capable of oxidizing, destroying, or absorbing a certain amount of morbid emanations from the wounds of the contained patients; but, if these emanations be developed too rapidly or too abundantly, the air becomes overcharged with poisonous matter, and then all the ill-effects of overcrowding at once develop themselves" in the generation of septic disease. He adds: "There is no evidence that an accumulation of *unwounded* patients, *to any extent*, can develop hospital

gangrene or pyæmia, whatever other diseases may thus be generated. Pyæmia could not have been generated in the 'Black Hole' at Calcutta."

To the evidence of the trained English hospital surgeon may be added that of the great French physiologist, Robin, who expresses himself concerning the causes of pyæmia as follows: "As to phlebitis, and the absorption of globules of pus, etc., this is all romance, as proved by the experiments which have been made in Germany, Italy, and especially by Savory in England. Putrid injections made on healthy dogs when they have been allowed to run free, with healthy surroundings, have resulted in temporary sickness only. When the dogs have been sick, closely confined, badly fed, or the subjects of repeated experiments, they have fallen victims to pyæmia—the result of molecular decomposition of the blood. In the same way, surgical patients from the country brought into the wards of a hospital, and breathing its infected air will, in spite of all precautions, become debilitated and anæmic, and in the end die of pyæmia." ("Dictionnaire," Littré and Robin, 1873.)

This, then, is the scientific basis for the *preventive treatment* of pyæmia, broader and deeper, even, than the protection afforded by antiseptic dressing for wounds, which, however, should not be neglected. Happily the two are not incompatible. Sir James Paget vouches for the clinical fact that the few cases of well-marked acute pyæmia he has known to recover were all exceptionally well supplied with fresh air. The blood rids itself of the altered products already formed in it by *ventilation* through the lungs, and no doubt, as Erichsen avers, by a process of oxidation.

Therefore oxygen of the purest quality and in the greatest abundance is to be supplied to surgical patients with open wounds. I do not advise you to go to the chemist for your oxygen, although the only objection to this would be that it might divert your atten-

tion from the resources so liberally supplied by nature. But get fresh air for your patients with open wounds, and supply it constantly, lavishly, without stint. Get it at all risks, but avoid these risks as far as possible by having it properly warmed, and by preventing draughts perceptible to the patient by which the animal heat might be too rapidly removed from the body. This bountiful supply of wholesome fresh air is the great secret, not only of preventing pyæmic blood-poisoning, but of the most effective aid to other remedial means—*none of which are so effectual.*

What are the chances of recovery in pyæmia? In the *acute form of the disease*, which is, unfortunately, the more common, *they are almost hopeless;* and yet, now and then, when it is least expected, a patient does get well. I have seen this result come about in two or three cases in a manner most unhoped for, and therefore should never despair of saving a patient.

The late Mr. Callender, in Holmes's "System of Surgery," states that, in the experiments in which putrid pus was injected into the veins of dogs, ecchymosed spots—the commencing-points of abscess—were almost invariably found in the lungs when the animals were killed a certain number of hours after the injection; but, when they were not killed, a large majority of the dogs got well—if they had been originally healthy and *were allowed to run free in the fresh air.* These results show that, in a healthy organism, the powers of life may, under favorable circumstances, surmount the effects of poison introduced into or begotten in the blood, if not excessive in amount or too often repeated. *It is the occurrence of successive waves of septic poison from an imperfectly disinfected wound, prevented by an imperfect supply of fresh air from being oxidized and carried off, which, in my opinion, explains the mortality of pyæmia.*

Under the head of *diagnosis* it is to be noted that pyæmia may be mistaken for *typhus*, and also for *ty-*

phoid fever, on account of the dull aspect and physiognomy of the patient. Dr. Wilks says that whenever his attention is called to a case of fever in the surgical wards he immediately suspects pyæmia. But the early repetition of the chills and sweats soon makes the distinction clear.

In this country *ague* is always suspected at the outset of pyæmia; but the absence of regular periodicity in the recurrence of the chills, and the more profound prostration of the patient, as well as the failure of quinine to break up the attack, soon render its true character apparent. The chills and sweats and yellow skin in *acute pyelitis*, in peri-cystitis after lithotomy, and in other phases of urinary fever, may cause doubt. By the physician, pyæmia might be mistaken for *pure pneumonia*, especially when cough and rusty expectoration are present, which are not an unusual sequence of the pulmonary embolism. He might mistake pyæmia for *acute rheumatism*, for the articular pains coincident with the formation of pus in a joint are frequently intense. *Chronic pyæmia* is to be distinguished from *hectic fever*, *rheumatic fever*, *gonorrhœal rheumatism*, and simple *abscess formation* after fever.

In the *treatment* of pyæmia in hospital practice, I would isolate the case at once—in a tent, if feasible, in the open air, except, perhaps, in midwinter.

The tendency to death is by exhaustion, through spoiling of the blood; this is to be resisted by liberal and systematic feeding with concentrated food and stimulants in moderate but frequently repeated rations: milk-punch, nutritious soups, oatmeal gruel, with wine. The blood must not only be aided to clear itself of poisons by ventilation, but it must be supplied steadily with the elements by which its substance may be most readily renewed—fatty, nitrogenous, phosphatic.

The condition of the other emunctories besides the lungs—the skin, bowels, and kidneys—is to be carefully watched, so that they may not fail in their duty. Na-

ture is apparently making an effort at elimination in the profuse and repeated sweats, as she does also by the tendency to diarrhœa. Bathing or sponging the surface with spirits to which a little ammonia has been added is of service. The kidneys are to be assisted by pleasant drinks, flavored by fruit-juices, and rendered light and easily digestible by the addition of soda-water. If a laxative is required, I prefer the phosphate of soda in gruel; the soda salts are in demand for renewal of the blood. Sir James Paget thinks that *liquor potassæ* favors the resolution of threatened abscess.

Of all drugs, quinine is most universally relied upon in this disease, and justly. It has no specific virtue, but it tends to lower the temperature and to sustain the vital force. Five grains every six hours is a good dose. Opium may be required to quiet restlessness or restrain diarrhœa. Bromide of sodium prevents the nervous tension sometimes caused by quinine. Phosphoric-acid lemonade and the iron gas-waters, with light wine, are useful and pleasant drinks.

CHAPTER XVIII.

Erysipelas.

ERYSIPELAS, which next claims our attention, is one of the most anciently known and universally recognized diseases of man. Its name, derived from the Greek, is used by Hippocrates, who describes the disease plainly, and speaks distinctly of its dangerous nature when attacking the womb of a pregnant woman.* Thus, even in the earliest ages of medicine, it was recognized that erysipelas might affect an internal organ, *and it was connected with puerperal fever.*

Popularly regarded as a local affection of the skin, where, indeed, it is most common and obvious in its manifestations, *erysipelas is in truth a febrile disease caused by the presence of a poison in the blood, capable of reproducing itself.* It has been proved in many authentic instances to be certainly *infectious* in its nature,† its *outbreak is preceded by a distinct period of incubation*, and it *is liable to prevail both in the endemic and epidemic form.* These are three good reasons for accepting the conclusion that the disease is due to a blood-poison.

In its simpler forms and in isolated or sporadic cases erysipelas is usually a mild disease, characterized by a solitary chill, subsequent frank fever of the continued

* "Si mulieri pregnanti erysipelas in utero fiat, lethale." Aphorism.

† The fifth part ("On Erysipelas," by Dr. Tilmanns) of Billroth and Luecke's "German Surgery," now in process of publication, contains, at p. 82 *et seq.*, a recent collection of cases proving the contagiousness of the disease.

type, and local inflammation confined mainly to the skin, with a tendency to get well in from six or seven days to three weeks. On the other hand, when it multiplies itself by infection, or becomes prevalent in any locality through the presence of a common source of poison, or is intensified by the coincidence of bad surroundings, erysipelas is likely to assume a more deadly character, the fever takes on a low type resembling typhus, the inflammation invades the connective tissue beneath the skin, internal organs are threatened, and there is a tendency to pus-formation, to local gangrene, and to death. The disease presents itself, therefore, in different aspects, each of which is to be examined.

The first and most important distinction to be noted is that which assumes to divide erysipelas into *traumatic* and *idiopathic.* As far as this division implies that the disease is liable to be *caused* by a wound, it is faulty; for, unless the peculiar poison that produces erysipelas be present, *there is no kind of wound known to surgery by which the disease can be produced at will.* Ricord, in visiting his hospital wards one day, remarked to his house surgeon, concerning a case of extensive chronic ulcer left by a chancroid, that he knew of nothing that could cure that ulcer short of an attack of erysipelas. It is a singular fact, familiar to hospital surgeons, that old ulcers, and even other lesions of the integument, frequently manifest a tendency to get well after an invasion of this curious disease. On this hint from Ricord, the house surgeon undertook to provoke an attack of erysipelas in this chronic ulcer by systematically applying to it rancid ointments and a variety of irritants, mechanical and chemical, but all in vain; he made the ulcer worse, but could not succeed in exciting an erysipelas. Some weeks afterward an endemic outbreak of erysipelas made its appearance in the wards and became prevalent. The man with the chronic ulcer was attacked by it, and narrowly escaped

with his life; but *during convalescence his chronic ulcer took on healthy action, and went on steadily to get well.*

When two or three cases of erysipelas have occurred in any locality—say, for example, in a ward of a hospital—a patient with a wound placed in a bed in this ward will be likely to be attacked by the disease, and the skin inflammation will show itself first at the wound.

I once trephined a woman, for what seemed to be traumatic epilepsy, at the New York Hospital. She had been sent to me for treatment by my friend Dr. C. R. Agnew. The patient had been struck by the corner of a flat-iron over the right parietal bone some months before, and her seizures had increased in frequency so that they were occurring almost daily. The nurse in one of the small wards near the operating theatre, kept for cases of recent operation, was a friend of the patient, and, although there had been several cases of erysipelas in that ward, I yielded to her entreaty and she occupied the little ward alone. On the third day after the operation she had an epileptic seizure, which evidently had substituted itself for the initial chill of erysipelas, for the scalp was invaded in a few hours. The case of erysipelas proved a mild one, and the wound healed without interruption. There were no more fits, and the patient was discharged apparently cured. Some years afterward she came to my clinic with a sick child, and, in answer to my inquiries, said she had had no more fits since the operation, except on two or three occasions, when, as she frankly confessed, she had taken a "drop of whisky."

A patient *free from surface-wound or sore*, similarly exposed to the infection of erysipelas, would also be liable to contract the disease, but the chances of escape would be greater; and the face, as the most exposed part, would be most likely to be attacked.

The term "traumatic," therefore, when applied to erysipelas, implies simply the presence of a lesion

which, by offering an avenue of entrance to the poison, has possibly invited or localized an outbreak of the disease, the real cause of which has been already present in the air or in the blood. In assuming the existence of a peculiar poison as the cause of erysipelas, the terms traumatic and idiopathic consequently lose the significance formerly attached to them. We may correctly speak of erysipelas with or without a wound, or of surgical or medical erysipelas. This change in nomenclature is all the more desirable for accuracy, as the question has been seriously discussed whether erysipelas ever occurs without the presence of some wound, however minute. (Gosselin, "Nouv. Dict.," art. "Érysipèle.")

A more important division of erysipelas is into the *simple cutaneous* and the *phlegmonous* varieties; in the former the skin alone, with local exceptions, is affected; in the latter the brunt of the disease is borne by the subcutaneous connective tissue.

An invasion of erysipelas, in any form of the disease, is announced almost invariably by the occurrence of a *chill*, accompanied sometimes by nausea and vomiting. The chill has most probably been preceded by a consciousness of not feeling well, by loss of appetite, "pain in the bones," or headache. The fever that follows is of the continued type, varying in intensity according to the severity of the attack and the type of disease prevalent at the time, with a pulse not remarkable for either frequency or force.

The chill and succeeding fever of erysipelas differ in no respect from those which accompany an invasion of an eruptive fever, or of pyæmia. The existence of a wound, or the knowledge that erysipelas is prevalent, may suggest the probable nature of the attack; but in the absence of these indications there is a symptom that rarely fails to foreshadow what is coming. As the occurrence of a chill in a surgical case is an event suggestive of danger, it is desirable to recognize at the ear-

liest moment what danger threatens, and this symptom affords an indication: *it is a marked tenderness and slight swelling of the lymphatic glands which receive the lymphatics from the neighborhood of the wound.* In a medical case, where the face is more likely to be attacked, the lymphatic gland in front of the ear (over the parotid), and the submaxillary glands, will be found to be decidedly over-sensitive. It is a curious fact that this glandular tenderness almost always precedes for some hours the redness of the skin in a part about to become the seat of erysipelas, and affords reliable ground for prognosis. It is explained by the anatomical lesions which characterize the disease: *the lymphatic plexus of the skin is the part of its structure which is first and principally involved in simple cutaneous erysipelas*, and the presence of irritating matter in these delicate vessels is shown by pain in the glandular centers to which the larger trunks converge—before any surface redness and swelling have become manifest. Hence tenderness is detected when firm pressure is applied, not only to the glands, but also over the main lymphatic trunks leading to them.

In from two to five or six hours after the chill, first there is pain on pressure, and then a slight blush of redness of the skin becomes perceptible. The patient is conscious of a local sensation of *burning and smarting in the affected part.* The redness increases, and swelling is added; the outline of the erysipelatous patch, *which is sinuous and irregular*, becomes elevated and well defined. Infiltration is evidently taking place into the substance of the inflamed skin, which becomes tense, tumid, and brawny to the touch. The finger, passed lightly over its surface, recognizes not only this, but also the distinct abruptness of its margin where it joins the sound skin.

This margin advances, with its variably curved and sinuous outline, in a generally irregular and uncertain way. It is necessary to note this feature of irregularity

in the mode in which a patch of erysipelas spreads, for local remedies are often credited with arresting the progress of the disease when, in fact, the arrest, as the result proves, is only a temporary halt, or it is coincident with advance in another direction.

The disease puts on a somewhat different aspect in certain regions: thus, in the eyelids, the scrotum, and in parts where the subcutaneous tissue is free from fat, it becomes distended with liquid exudation to a much greater degree than in denser tissues—as of the scalp, where the swelling often is hardly perceptible.

Erysipelatous inflammation of the skin reaches its height in from three to six days. At this period the surface communicates to the finger a distinct sensation of granular roughness like that of the skin of an orange. This is due to the effusion of fluid in minute quantities beneath the epidermis. Sometimes this effusion takes the form of little vesicles barely visible to the eye; then, again, they are larger, like the vesicles of herpes, and they often run together, forming *bullæ*, or blisters, of some size. Their serous contents are colorless or watery, sometimes yellow, and even jelly-like, as in a blister produced by cantharides. The vesicles of erysipelas may even contain coloring matter of the blood in solution, looking like "blood-blisters." When these dry into crusts or scabs, as they all do shortly, their purple color is liable to be mistaken for spots of commencing gangrene, but their sensibility to the prick of a needle will show that the skin beneath them is still living.

The general tint of redness of the inflamed skin in erysipelas varies according to the type of the case; it is sometimes so bright as to recall the old English name for the disease, "the rose"; in persons with feeble circulation it is of a duller red, and not infrequently tawny, dusky, and even livid.

After the inflammation has reached its climax the color of the skin becomes more yellowish, its extreme

tension is relaxed, and soon another feature, *desquamation of the cuticle*, begins to manifest itself. After this the part gradually returns to the aspect of health.

The shortest period in which these several phases are accomplished is about nine days. But for the uncertain capriciousness which characterizes the advance and progress of the skin inflammation, and its strong tendency to recurrence after it has apparently died out, which are distinctive features of the disease, this period of nine days might be regarded as the natural duration of a simple cutaneous erysipelas. Each successive advance, however, requires very nearly the same length of time to run through its phases, and, until the last portion of skin attacked has reached the stage of desquamation, we can not be sure that the disease is at an end. Hence the duration of a case of simple erysipelas is not infrequently prolonged to a fortnight, or even longer.

Each successive advance of surface redness, however, is less acute in character than that which preceded it, as though the disease were exhausting its force. This is in conformity with the diminishing degree of intensity of the fever, as marked by the thermometer. During the chill the *temperature* runs up rapidly to 103°, 104°, and 105° Fahr., or even higher, according to the gravity of the attack, and maintains itself, with the usual slighter morning and evening fall and rise, until the fifth or sixth day, when the inflammation in the patch of skin first invaded has reached its climax ; and coincident with this there is usually a sudden and decided fall, in some cases even below the normal standard. After this the temperature may rise again once or twice, or even more frequently, just as the skin inflammation may happen to advance ; but it never reaches the first figure, and its fall always takes place sooner.

The pulse, which as a rule is characterized by lack of force and is rarely very frequent, is not so good a guide in prognosis as the thermometer. During the height of the disease there is a sort of subdued rest-

lessness or half-stupor, often slight wandering, not infrequently positive delirium, and a dry tongue. The bowels are more often confined than relaxed. The urine not infrequently yields tube-casts of renal epithelium, as in scarlatina.

During the progress of a simple erysipelas the wound around which it has been developed yields less pus and presents a drier aspect; but in other respects, as a rule, the process of repair continues to advance—more slowly, perhaps, but steadily and soundly.

In an ordinary case of *erysipelas of the face*, which is the most common form of the disease in its medical aspect, after the initial chill a red patch makes its appearance, almost always over one of the nasal bones or upon the contiguous skin of the cheek, and extends upward and outward to the forehead and side of the face, or more frequently across the bridge of the nose to the other side of the face. The very considerable swelling that follows, and the intense redness, often accompanied by blisters, of the inflamed skin, cause hideous deformity of the features, and give rise very generally to exaggerated fears on the part of those who have never seen the disease before.

The extent to which the scalp will become involved is uncertain, but it rarely escapes. It is exceptional, however, for erysipelas of the face to extend to the trunk. *The epidermis always exfoliates from a surface which has been the seat of erysipelas.* After the scalp has been affected, the hair usually falls. *The appearance of exfoliation is the surest indication that the erysipelatous inflammation has reached its term.*

After death from simple cutaneous erysipelas the redness of the skin will be found to have entirely disappeared; it is replaced by a yellowish pallor. In the dead-house we are struck by this change. But the affected skin is somewhat thickened, and can be distinguished from the surrounding healthy surface by the slight elevation of its margin when the finger is passed

across it. There may be some crusts from blisters or gangrenous spots upon it, and it takes on a livid tint and cadaveric change somewhat in advance of the neighboring healthy integument.

Vulpian examined microscopically some specimens of skin taken from the front of the neck, where the inflammation was most intense, in a woman of seventy, who died on the seventh day of an erysipelas of the face. The skin was decidedly thickened, and the thickening was entirely at the expense of the true skin, the epidermis being unaltered, even in its deeper stratum—the *rete mucosum. The increase of thickness was due to the infiltration of the skin with leucocytes, which were equally distributed throughout its substance—so closely indeed at many points as to touch each other and obscure its fibrous structure;* they were most numerous near its papillary surface.

Other microscopists have found the same infiltration of the skin with pus corpuscles, especially Volkmann and Steudener, after observations made upon some sixty cases during an epidemic at Halle, in 1868. Virchow had already assumed that every erysipelatous or diffuse inflammation has the peculiarity of early affecting the lymphatic vessels, and that "in such a case we may feel assured that an increase in the number of the colorless corpuscles is taking place."

More recently, Lukonsky, a pupil of von Recklinghausen, of Strasburg, has demonstrated the presence of bacteria and monads in unusual numbers in parts affected by erysipelatous inflammation; so that, *at present, it is the prevalent opinion that the poison is absorbed through the lymphatic plexus of the skin, which is thus primarily affected; that the capillaries become engorged by afflux, in consequence of the presence of the poison; and that the cell proliferation follows.*

Thus in simple erysipelas there is certainly copious infiltration of the true skin with pus-cells; and there

are also occasional exudations of serum in the thickness of the epidermis separating its horny layer from the rete mucosum, forming vesicles, or bullæ. As this form of the disease gets well in the great majority of instances by resolution, or *defervescence*, what in this event becomes of these leucocytes, or pus-cells? They are probably absorbed by the lymphatics.

The mode of death in simple erysipelas is by coma or by failure of the heart. The blood is found in an altered condition; it is unusually fluid, and forms soft coagula; the lungs are intensely engorged, presenting the appearance known as splenization; the spleen itself is soft and diffluent. Emboli or plugs of leucocytes were found by Bastian in the smaller vessels of the brain after death by coma in erysipelas of the face and scalp. The arachnoid membrane shows diminished transparency, and the fluid in the sub-arachnoid spaces is increased in quantity.

These are the anatomical lesions found in the simpler forms of the disease. They would hardly be complete without allusion to the alterations of the muscular tissue which have been quite recently observed, which, according to Hayem, are simply *the result of a poisoned condition of blood and consequent high temperature, to which causes directly death, when it occurs in simple erysipelas, is to be attributed.*

Concerning certain *complications* and *varieties* of simple erysipelas a few words are to be said here. Red lines, marking the course of the larger lymphatic trunks, are sometimes visible as they converge toward the nearest glands, at the beginning of an outbreak. If the presence of poison in the microscopic lymph-channels has the power of exciting *them* so greatly, it is natural that the larger trunks which convey their contents should also suffer. To this appearance of red lines in and under the skin, attended by pain on pressure, Velpeau gave the name of *angeioleucitis.* The simpler name of *lymphangitis* is more employed at

present. Now, the relation between cutaneous erysipelas and lymphangitis—between inflammation of the lymphatic capillary plexus and the same affection of the larger lymphatic trunks—would seem to be so close as to constitute absolute identity ; and yet the two conditions present such different features that, until we know more of the causes of this difference, it is wiser for us to retain a separate name for each, and to consider lymphangitis, in the present connection, as a complication or variety of erysipelas. It is to be remarked that the affection of the lymphatic trunks is frequently, to all appearance, absent in erysipelas, and, when present, does not add to its gravity ; and, again, that lymphangitis, which often occurs alone, and without any connection with erysipelas, is a mild affection, almost always the result of an injury—often of a trifling one—and that it usually gets well promptly and entirely, causing abscess in the course of the inflamed vessel only in exceptional cases, or in the gland in which it terminates ; or, still more rarely, involving the deeper lymphatic vessels of the affected part.

Another not infrequent complication is abscess. Toward the eighth or ninth day of a simple erysipelas, instead of fading uniformly in tint, some points of the inflamed surface may be noticed where the color is a trifle more livid, at which the skin has put on a smooth, shining appearance, and gives evidence, to the touch, of more acute tenderness and more tension than elsewhere. Shortly these symptoms become more evident, and, on examination, fluctuation is detected. The pus, when evacuated, is thick and healthy, and the cavity of the abscess, for such it is, shows a disposition to consolidate promptly. After erysipelas of the face, the eyelids, especially the upper, are often the seat of suppuration occurring in this manner. But the pus is limited by a barrier of healthy granulations, and the favorable issue of the case is not much delayed by this complication—which should not for a moment be con-

founded with the more diffuse pus formation characteristic of *phlegmonous* erysipelas.

Gangrene of the skin is also liable to make its appearance at points during the height of simple erysipelas, and this complication presents itself under two very different aspects. In the first, upon the delicate skin of certain localities where there is subcutaneous fat—e. g., the eyelids, or scrotum. Here, through excessive distention of the subcutaneous connective tissue by œdematous infiltration, the nutrient vessels of the skin become overstretched, their circulation is interrupted, and a patch of skin perishes. This form of gangrene is not dangerous, and may be prevented, or certainly limited, by timely incision of the skin. As a complication it is somewhat more serious than abscess, for, if not promptly met by the knife, the destruction of tissue may be so considerable as to necessitate a prolonged effort at repair. I have seen the whole scrotum swept away in this manner, and the testicles denuded.

In the second form of gangrene liable to complicate erysipelas, eschars form spontaneously, without any such local cause as I have just described—*the result of a general lack of vitality.* The gangrenous patches make their appearance about the fifth or sixth day of the disease, at the points of greatest inflammation, coincidently with a sharp rise of the thermometer, dryness of the tongue, and a faltering pulse. The concurrence of these symptoms involves a grave prognosis; such cases are not very rare in hospital practice, and would be likely to follow typhus fever or some exhausting disease, or to occur during the endemic prevalence of puerperal fever. I saw it in the adjoining hospital during the typhus epidemic of 1846. *In this complication alcoholic stimulus is especially indicated.*

There is a form of local gangrene commencing in a limited swelling of extreme hardness which attacks the genitals, or the cheeks, of badly nourished children,

described under the names of *noma* and gangrænopsis, which it has been sought to connect with erysipelas as regards identity of cause and pathology; but the present condition of our knowledge hardly justifies this assumption.

The very common occurrence of erysipelas makes its *diagnosis* a matter of importance, for the name is very much misused popularly, and rather loosely employed even in the profession. Popularly, several forms of skin disease are miscalled erysipelas, but *erythema* alone is liable to be mistaken for it by the practitioner. This affection generally occurs as a consequence of indigestion or some nervous perturbation, and may merge into the wheals or red blotches of urticaria or nettle-rash. It may be ushered in by a slight chill and rise of temperature, but these are rarely well marked, and it is sudden in its outbreak and disappearance—which is very different from the intense and cumulative spread of erysipelas.

A lady of delicate skin and full habit ate a pork-chop at breakfast, and within two hours her face, throat, and neck had broken out into a continuous sheet of vivid redness. There was little if any swelling of the skin, and no elevation of the edges of the red surface, which, under a dose of rhubarb and soda and a warm bath, in twenty-four hours had entirely disappeared, leaving some œdema of the eyelids and a slight itchiness of the affected surface. This was *erythema simplex.*

The redness of the swelled legs in the dropsy of Bright's disease is *erythema læve;* it often shows itself around a varicose ulcer of the leg after fatigue in walking, or occurs as a sudden redness about the genitals. There is a rarer form of chronic erythema, with thickening of the skin, more often affecting the face, and recognized by its chronicity; it does not itch or vesiculate. In *erythema nodosum* there is always ecchymosis. All of these are liable to be mistaken for cutaneous erysipelas.

The *treatment* of erysipelas ranges itself under two heads: *prevention*, and *cure*. Instead of cure I should say, rather, *alleviation;* for there is no remedy known at present by which this disease may be cured. But prevention is all-important; it is available mainly in the *avoidance of infection*, and especially in the management of patients who are the subjects of wounds or surgical operations in hospital practice.

The crowding together of patients suffering from open wounds, with insufficient supply of fresh air and with defective cleanliness in the management of dressings, undoubtedly favors the development of the erysipelatous poison. It is under these circumstances especially, which in some degree are unavoidable in every hospital, that the virus or poison of erysipelas is likely to be generated, and the vitality of patients at the same time lowered to the point at which it is most readily received into the system. The amount of fresh air required by a sick person is much greater than is generally supposed; and so also is the liability of the sick to be poisoned by each other. Erysipelas, then, like pyæmia, is to be prevented by *scattering* patients with open wounds and securing for them a plentiful air supply. This is our duty. You will see shortly that we are almost powerless to cure the disease when once it has developed itself, but we have it largely in our power to prevent it.

Separate and isolated apartments should be provided in connection with every hospital to which cases of erysipelas are admitted.

The adoption of this precaution has notably diminished the frequency and the malignancy of the endemic outbreaks of erysipelas formerly so common. When I was a dresser in la Charité, in Paris, forty years ago, cases of erysipelas were received into the surgical wards without question, and the same was done here in Bellevue Hospital when I became one of its surgeons thirty years ago. Even so recently as this the conviction as to

the infectiousness of erysipelas had not yet acquired practical force.

Adequate carefulness in regard to materials used in common for dressing has come into observance still more slowly. Professor Alonzo Clark, one of the senior physicians, stated within a few years, at a meeting of the Medical Board of Bellevue Hospital, that a sponge used in washing the face of a patient with erysipelas was afterward employed in administering nitrite of amyl, by inhalation, to three patients with phthisis. They all contracted erysipelas of the face.

Dampness has been observed to favor the occurrence of erysipelas. In the old French hospitals the tile floors were always dry rubbed and polished, and the use of water forbidden. In the old Hôtel Dieu Hospital, lying across the river Seine, the vaults were liable to inundation from spring freshets, and at this time an endemic outbreak of erysipelas was always developed in the wards. In our hospitals the damp weather of February and March has been found to favor the disease.

Dry, warm air undoubtedly acts as a preventive.

Of equal importance is the conviction, which has not even yet acquired enough practical force, although abundantly susceptible of demonstration, that the disease may be conveyed by the medical attendant—notably by the obstetrician who goes from the bedside of an erysipelatous patient to the lying-in chamber, where he is perfectly competent to introduce a poison which may become the cause of puerperal fever and death.

I have said that medical science has no positive cure for erysipelas. We can alleviate the sufferings it causes, we can moderate the intensity of its symptoms as we watch it through its natural course to its usually favorable termination, and often, by skillful and judicious interference—as by timely incisions, or tracheotomy in œdema of the glottis—we have it in our power to save life; *but we have as yet no antidote for the blood-poison to which the essential features of the disease are due;*

and we can not cut it short. The almost interminable list of remedies introduced during the past century with high praise, tried for a time and then dropped, tells the story sufficiently. Among these I may mention the following, without introducing the names of their too sanguine advocates: Bird-peck punctures and scarifications, followed by pressure; bleeding, emetics, and purgatives; blisters; nitrate of silver; tincture of iodine; mercurial ointment; mercurial purgatives; sulphide of calcium; "the bark"—Fordyce's great remedy; and, more lately, quinine, which, in a full dose, it has been rashly asserted, will cut short the disease. In 1839 Velpeau became so enthusiastic as to the virtues of sulphate of iron, which he used internally at la Charité, and in lotion and ointment externally, that the government ordered its disuse because it spoiled so many sheets.

Before this, Bassereau—to whom we owe so much for his able investigations concerning syphilis—published in 1832 a *résumé* of the practice of Velpeau, with whom he was house surgeon. During three years, he says, we have had eighty-nine cases of simple erysipelas, for the most part following wounds; of these, Velpeau treated nine by mercurial ointment, five by other greasy applications, twelve by emetics and purgatives, eighteen by blisters, fourteen by blood-letting, seven by cauterization, two by incisions, and twenty-two by emollients—*without any success whatever from any of these remedies; the disease was not only not arrested, but not even apparently in the slightest degree modified by them.*

In an ordinary case of cutaneous erysipelas, after having secured the best conditions for the patient as to nursing, feeding, and hygienic surroundings, and after obtaining, by the mildest efficient means, a proper evacuation of the bowels, I think the best attitude for the attendant to adopt is that simply of intelligent watchfulness—what the French call "expectation." The idea of cutting short the disease is entirely untena-

ble. The sulphate of quinine will not do it. The early and free use of this drug, however, is undoubtedly of service, save in the exceptional cases in which it disagrees. It seems to act by directly sustaining the powers of life. This is also true, in a somewhat different way, of the tincture of the sesqui-chloride of iron, which is well borne in liberal doses. This drug was introduced into general use as a remedy for erysipelas nearly thirty years ago by the Doctors Bell, of Edinburgh, who ascribed positive curative virtues to it when used in liberal doses—say of twenty drops every two hours.*

They used no local application but dry powders and cotton wadding. It is highly praised by Dr. Reynolds in his excellent "System of Medicine." †

He recommends the following prescription: ℞. Chloric ether, tincture of sesqui-chloride of iron, and glycerine, of each forty drops; give in a wine-glass of sweetened water every four hours. De Morgan ‡ speaks favorably of it. Billroth does not mention it, while Parkes and the French and German authorities have nothing to say in its praise.

One of the most cleanly and soothing applications to the inflamed skin is a dry absorbent powder, such as parched flour, rice flour, starch, or toilet powder. If a lotion is preferred, that of lead-water and laudanum is sanctioned by the widest use. Goulard's cerate and vaseline are the best greasy applications; the latter I have found in some cases to relieve the smarting and burning pain of the inflamed skin. Cotton-wool has the advantage of preserving an even temperature. Sir James Paget found collodion in his own case effectual in relieving itching and smarting, from which he suffered greatly.

After a few days (or, during an epidemic or when typhus fever is prevalent, from the beginning of the

* "Edinburgh Monthly Journal of Medical Sciences," June, 1851.
† London, 1866. ‡ Holmes's "System of Surgery."

case) alcohol internally in some form will be probably advantageous. The indication for its use is the recognition in the heart's action of a tendency to failure of force which is not a usual feature of erysipelas.

During the typhus epidemic of 1847, when I was on active duty in the adjoining hospital, erysipelas, which was very prevalent during the latter months of winter, tended to terminate fatally by asthenia toward the end of the first week. It was found necessary to give stimulants early and freely, and this course was followed by the best results.

Later in the disease there is a tendency to death by the brain, with delirium and coma. These symptoms are most commonly due directly to the circulation of poisoned blood in the capillaries of the brain, or to lack of an adequate supply of pure blood. They are undoubtedly aggravated by the cerebral congestion which results from pressure through swelling of the glands and tissues of the neck upon the great veins emerging from the base of the cranium, or from embolic plugging by leucocytes, as found by Bastian in a fatal case.

Brain symptoms in erysipelas do not necessarily indicate meningitis from extension of inflammation from without, as is popularly supposed. Nor do they call for bleeding, leeching, shaving of the head, and blisters. The diagnosis of meningitis in erysipelas is obscure; if present, it is due to blood-poison rather than to extension of local inflammation from the outside to the inside of the cranium; and it is almost inevitably mortal. This being the case, the occurrence of head symptoms does not contraindicate the persistent administration of iron and milk-punch when they seem to agree.

On the whole, with good surroundings hygienically, good nursing, judicious feeding, and, if the pulse flags, a moderate amount of stimulus, you will probably pull your patients through in ninety-five cases out of a hundred of simple cutaneous erysipelas.

CHAPTER XIX.

Phlegmonous erysipelas—Malignant erysipelas—Epidemic erysipelas—Hospital gangrene—Acute phagedæna—Glanders.

BUT this statement is not true of *phlegmonous erysipelas*, which we have next to consider, a variety of the disease in which the connective tissue beneath the skin is affected, as well as the skin itself. The phlegmonous form of erysipelas does not usually extend beyond the subcutaneous connective tissue, being limited by the deep or muscular fascia; but in bad cases it may extend beneath the deep fascia among the muscles, and involve the whole thickness of the limb. When this occurs, the deeper lymphatic vessels which accompany the main arteries of the limb have become involved, so that complication with *lymphangitis* occurs also in this variety of erysipelas.

While in the simple or cutaneous form of the disease we found suppuration occurring only exceptionally, as in abscess of the eyelids, in phlegmonous erysipelas suppuration is the rule; and the pus formation *manifests for the most part a diffuse or spreading character without limitary walls.* The French speak of this form of inflammation as "diffused phlegmon." By some English writers it is called sub-fascial inflammation.

Phlegmonous erysipelas is, therefore, more destructive in its local manifestations than the simple cutaneous form of the disease, while its general or constitutional symptoms are equally significant of a poison acting on the blood.

Phlegmonous erysipelas rarely occurs except as a

complication of some traumatism more or less directly involving the subcutaneous connective tissue. Laceration or crushing of a finger, for example, is a common and characteristic cause of phlegmonous erysipelas of the fore-arm; and the consequences which, especially in hospital practice, so often occur in compound fracture of the leg, in which the deeper planes of connective tissue of the limb are lacerated and exposed to the air, are only too familiar. But the underlying cause of this grave form of disease, which, according to Dupuytren, "counts more victims than any other form of localized inflammation,"* is to be found in the subtile septic agent by which the blood is altered; for wounds, as I have said already, although they may invite erysipelas, pretty certainly do not cause it. Robust health and pure air have their influence in warding off the effect of this poison, while the opposite conditions favor it. Among well-to-do people in private practice it is comparatively rare; in the surgical wards of hospitals it is common.

The earliest symptom of phlegmonous erysipelas is local pain, followed by swelling; and with these, usually, tenderness of contiguous lymphatic glands; then a chill occurs, and subsequently surface redness at the seat of pain. Antecedent general malaise, a recent wound, or some festering sore in which repair has been delayed or interrupted, are generally features of the case. The chill is almost always well-marked, and it is liable to be repeated later, when pus is about to form in the connective tissue. The fever, although of the continued type, is liable to be mistaken for intermittent, through recurrence of chills. It is marked by high temperature, hot skin, thirst, restlessness, and a pulse both quick and frequent; and later, in grave cases, by low-muttering delirium and partial insensibility. It is accompanied at first by nausea and loathing of food, suspended functions of stomach and bowels, and a tongue covered by a moist, yellow, adhesive coating—

* "Leçons orales," t. iv, p. 445.

very commonly with a black stripe down its center, and a decided tendency to dryness as the disease advances. The local redness of the skin is less bright, and its margins are not so distinctly raised as in simple erysipelas. The pain is an exquisitely keen soreness, accompanied by tension and throbbing, but often the patient's sensibilities are dulled by stupor. At first the surface redness will disappear under the pressure of the finger, which leaves a temporary depression, or pit, indicating the presence of subcutaneous œdema; but after a few days there is a degree of brawny hardness developed, which prevents pitting, and the swelling becomes general and very considerable, so that if a limb is the seat of the disease it is often doubled in size.

The symptoms, both general and local, go on steadily increasing for five or six days, at which period there is an apparent arrest in their progress, and the practitioner of limited experience may delude himself with the idea that the inflammation has reached its height and that resolution is about to take place. This anticipation will prove delusive. Resolution in phlegmonous erysipelas is a rare occurrence. The lull in the symptoms really means that pus has formed beneath the skin. It means more than this—namely: that more or less connective tissue under the skin at the affected part *has died.* The pus effused into the substance of this dead connective tissue—which is visible to the naked eye when it is cut into and exposed—if its presence has any significance, means an effort at elimination of the tissue which has died. As stated recently by Cornil and Ranvier, the French pathologists,* "the inflammatory symptoms in *diffused phlegmon* are so intense that great masses of connective tissue, unable to bear the usual process of disintegration, are stricken at once with death, and forthwith act as foreign bodies upon the surrounding parts. *To speak accurately, according to these pathologists, diffuse phlegmon is a true necrosis*

* "Histological Pathology," Philadelphia, 1880, p. 451.

of the connective tissue, and offers a great analogy with suppurative osteo-myelitis. Accordingly, when the parts are examined, sloughy masses of tissue are found surrounded by, and macerated in, pus."

Now, therefore, if, in a case of phlegmonous erysipelas, toward the fifth or sixth day the temperature should fall, the local symptoms appear less urgent, and the pulse diminish in tension and frequency, these phenomena are to be interpreted, not as evidence that the disease is subsiding, but rather as significant of a recoil —so to speak—of the vital force in face of a catastrophe, viz.: the death of a noticeable amount of tissue, and the consequent necessity for an effort at its elimination and subsequent repair. This can only begin when the stress of the disease has abated, and when the tendency to death of connective tissue has ceased. Then the suppurating cavity forms for itself limitary walls, and behaves like an ordinary abscess.

About this time also the general aspect and condition of the patient is suggestive of necessity for supporting treatment, perhaps of an increase of stimulus; the blood, impoverished by the poison, requires renewal.

Locally, the hardness and tension of the swelling is replaced by a sensation of uncertain softness, more perceptible at some points than others, and producing a general feeling of "bogginess." The stretching, or absolute rupture, of the vessels by which the integument receives its blood-supply is followed sooner or later by the appearance of altered patches upon its surface, at first livid in color and then black and gangrenous. Through the breach thus effected by gangrene and subsequent ulceration an avenue of escape is opened to the pus and dead material beneath. But this process, although in reality conservative and tending to eventual repair, is slow, painful, wasteful of tissue, and accomplished with great effort by the weakened organism. Here the art of surgery may intervene to aid nature with great advantage to the patient. In fact, the experienced

surgeon, already recognizing the impending necessity, *will have employed the knife to make free openings in the skin as soon as the sensation of "bogginess" has announced the formation of pus; he will not have waited for fluctuation.* By this timely aid, gangrene and ulceration of the integument will have been averted, and the great constitutional irritation that accompanies the process, and much loss of tissue, will have been saved.

The appearances presented by the cut surfaces, which should embrace not only the skin but the distended tissue beneath it, show clearly the morbid changes which have taken place. Instead of a soft, extensible web—the ordinary aspect presented by healthy connective tissue—the edges of the incision disclose a yellowish-white, soft-solid substance somewhat resembling raw, fat pork, with minute yellower spots of fat, and perhaps also of pus, in its meshes. There is little bleeding from the substance of this solidified connective tissue, for it is mostly, if not all, quite dead. But from the dilated blood-vessels of the skin divided by the incision there is a free gush of blood, which, however, is only momentary. The edges of the incision retract and gape markedly, and the neighboring skin is thrown into wrinkles, showing the very considerable degree of tension to which it has been subjected.

Through the openings thus accomplished, whether by the timely aid of the surgeon or by the more tardy destructive efforts of nature, a sanious, oily, ill-formed pus escapes, which floats out at first smaller particles of dead tissue, and later, in bad cases, helps to eliminate great masses of sloughy connective and adipose substance which resemble wads of wet tow. If incisions have been made judiciously as to location, and sufficiently large and numerous, they will suffice to give exit to the dead material; if not, the openings will enlarge spontaneously by further sloughing of the skin. Through these, after a time, the walls of the cavity with-

in will become visible, and, if the case is progressing favorably, they will be seen to be clothed with granulations. Little bands may be noticed by which the skin is still attached to the parts beneath; these consist of blood-vessels which have escaped death through exceptional power of resistance, and they should be carefully respected.

Thus it is evident, I trust, that in this form of erysipelas the skin is in danger of destruction by gangrene and ulceration, not through intensity of inflammation—the usual explanation—but because its nutritive supplies have been cut off through fatal lésion of the underlying connective tissue; and it is also apparent why early and free incisions are successful in averting this danger.

The sloughy masses thrown off in phlegmonous erysipelas, when examined under the microscope, show portions of white fibrous tissue in a state of partial solution, yellow elastic threads unchanged, pus corpuscles in various phases, oil globules and fatty particles mingled with detritus, mainly of blood-vessels and blood.

The cause of death of connective tissue in phlegmonous erysipelas is the same as that which, in the simple cutaneous form of the disease, produces the intense inflammation of the skin—namely, a poisonous influence acting upon it through the lymphatics and the blood. There is this great difference, however, in the effect of this poison upon the skin and upon the connective tissue, that while the external integument, through its greater vascular resources and higher organization, is able to throw off the poison and return, usually with promptness, to the condition of health, the connective tissue beneath the skin, when it bears the full force of the poison, tends to die outright and at once.

Recovery after phlegmonous erysipelas is slow and imperfect. There is necessity for genesis of new connective tissue and new blood-vessels, not only to complete the numerous cicatrices of the skin, but to replace

the subcutaneous tissues which have been destroyed. For the perfect development of these tissues, out of the jelly-like mass of embryonic or granulation substance left after external healing is to all appearance completed, a long time is required. Hence, especially when the whole thickness of a limb has been invaded and its inter-muscular septa destroyed, its muscles and tendons are more or less completely glued together in a solid mass, so that a fore-arm thus spoiled is for a long time little better as regards its function "than the flipper of a sea-turtle"; and many weeks must elapse before the complete development of the newly formed connective tissue will restore flexibility and suppleness to integument, or permit the numerous muscles of this segment of the limb to move upon each other so as to confer mobility again upon the fingers. Even the muscular tissue itself may have suffered through interrupted nutrition in consequence of destruction of the parenchymatous web of connective tissue in which it is imbedded. In this case recovery of the function of a limb is next to hopeless, especially if its joints are also stiffened. Finally, an articulation may be involved in suppuration; or, as happens not infrequently, the amount of general damage sustained by a limb is so extensive that even external cicatrization can not be accomplished; or destruction of tissue has spread so widely that the amount of consequent suppuration threatens life. Under these circumstances, amputation, when feasible, becomes a necessity.

In addition to what has been already said concerning the treatment of the disease in its simpler form, it remains for me, in connection with the special measures required by phlegmonous erysipelas, to urge upon you the importance of the early and free use of the knife.

Suppuration is to be watched for and detected as early as possible by palpation in the localities where it is most likely to occur. When fluctuation, or even an unusual degree of tension, or the peculiar condition

called *bogginess*, is detected, incision should be made without delay—for destruction of tissue by gangrene is imminent, and it can only be arrested by this remedy.

You are to remember that the necessity for incision is not an exceptional complication here, as in the simple variety of the disease, but that it is the regular remedy required in all cases. It is the only means we have at our command to save the patient from indefinite extension of the disease subcutaneously, and from consequent sloughing of the integument. By resorting to it we are anticipating the sloughing of the integument, which is nature's resource. Remember, also, that the use of the knife is almost always deferred too long by the private practitioner to secure its full benefit. By the experienced hospital surgeon it is employed promptly, generously, and in full confidence of the benefit to be derived from it.

The best form of incision is that which traverses the whole thickness of the skin and is from one to two inches in length, and the incisions should be as numerous as the extent of the tension justifies—taking the benefit of any doubt in favor of an additional incision. *It is a common error to make them too small and not deep enough.* The thickness of the subcutaneous layer of tissue is enormously increased.

To save blood, have little compresses or wads of lint or sponge ready to be applied promptly and firmly to each cut as it is made, to control the first gush, which may be free, but with this precaution it ceases at once. Any number of incisions can be thus effected in rapid succession within a few inches of each other by the aid of dexterous assistants, so that, with entire safety, the tension of the part and the progress of the disease may be relieved at once, with an insignificant loss of blood.

After incision, the part may be enveloped in cotton, and moderate, equable pressure is admissible. The next

day it may be soaked in the local warm bath, and afterward dressed either with yeast poultices or dry dressing, according as the morbid process has been arrested or not. If indicated, further incisions should not be spared. When the sloughs have come away and granulations are visible, dry dressing with gentle pressure is required.

Meanwhile, generous diet, with quinine and iron, is usually advisable; and it is very desirable to get the patient out into the sunshine and fresh air at the earliest possible moment.

Now, I can not complete an outline of the subject of erysipelas, and leave upon your minds the impression I desire to leave as to the nature of this disease, without speaking of another of its varieties, which has been called *malignant erysipelas.* In this form the poisonous nature of the disease is manifested in its greatest intensity, and with symptoms which justify the appellation of malignancy. It occurs when erysipelas is prevalent in an endemic form, and in localities of an unhealthy character where sanitary and preventive measures have been neglected, and its mortality is proportionally great.

The features of malignant erysipelas recall vividly those which I have recounted as characterizing the gravest forms of dissecting wound poisoning and the effects of serpent venom. Certain phases of this disease were ably described by Duncan, of Edinburgh, in 1817, under the name of "diffused inflammation of the cellular tissue" (meaning by this term what we now call "connective tissue").*

It is also set forth in some of its aspects in the classical cases of death from dissection wounds reported by Colles, of Dublin, of Professor Dease and Mr. Shecketion, the anatomists.†

In an interesting report of cases by an English army

* "Ed. Med. Chirurg. Trans."

† "Dublin Hospital Reports," vol. iii, p. 203.

surgeon I find the following circumstantial record in which the disease is described with evident fidelity.*

It occurred in a spontaneous outbreak of erysipelas which took place in an old barrack occupied by a portion of a British regiment in Glasgow, Scotland, in the months of March and April, 1837 :

Private Wilson, a healthy man of thirty-nine, had been engaged, as hospital orderly, in nursing and applying fomentations to a case of ordinary erysipelas of the face which terminated fatally two days before. His first symptom was a sore finger, originating from a barely recognized puncture near the nail, which became excessively painful, and gave rise to rigors and feverishness during the night which followed. On the next day there was local pain, great anxiety, distress, and restlessness, with hurried respiration and pain in the axilla and side of the chest; the pulse was 80 and soft, and the tongue furred, expanded, and moist. On the third day there were small blood-blisters on the finger, the back of the hand was slightly swollen, a few lymphatics were seen running along the ulnar side of the fore-arm toward the elbow, and on the arm there were some unconnected patches of redness. There was great tenderness in the axilla, with deep redness of the integuments extending along beneath the clavicle to the median line; the pectoral muscle was slightly swollen; there was increased anxiety and oppression and slight cough; pulse 84, full and soft. Deep incisions were made in the finger, barely a drop of pus escaped, and but slight relief followed. On the fourth day there was more swelling about the pectoral muscle and increase of pain; pulse 100, easily compressible; bowels costive, tongue loaded. There was a restless night, and on the fifth day redness

* "Report of Consecutive Cases of Traumatic Erysipelas and of Diffuse Inflammation of the Cellular Tissue, the Latter from the Absorption occurring in the Hospital Practice of the 79th Regiment at Glasgow," etc. By D. MacLachlan, M. D., Asst. Surg., etc., "Ed. Med. and Surg. Jour.," 1837, vol. ii, p. 352.

of skin had extended and now occupied the greater part of the right side of the chest, with more swelling and tenderness of the pectoral muscle; more lymphatics were seen on the hand and fore-arm, while the arm remained almost free from pain or redness. The symptoms steadily grew worse, with greater anxiety and distress and fits of profuse sweating, and the pulse rose to 120. There was no discharge from the finger, and nothing like fluctuation could be detected anywhere. Finally there was acute pain in the chest and abdomen, the pulse fell to 100, he began sinking, and expired on the seventh day. I have detailed this case as nearly as possible in the words of the narrator, omitting everything relating to treatment. This consisted mainly in purgatives and mercury carried to salivation, after the fashion of the day in inflammatory diseases. As the reporter ingenuously remarks, "the treatment seems to have done harm rather than good."

The body was examined twenty-four hours after death. The sheath of the flexor tendon of the finger was here and there infiltrated with purulent matter. From this to the axilla and the insertion of the greater pectoralis muscle there was no trace of disease. The "cellular tissue" in the axilla and on the side of the chest was red and infected. A section of the pectoralis muscles showed the inter-muscular "cellular substance" disorganized, softened, and infiltrated with pus, as was also the case beneath the muscles. There were patches of gelatinous softening noticeable in the intercostal muscles; opposite to one of these patches both layers of the pleura were inflamed and covered with exudation.

Another soldier, aged forty-three, assisted at this post-mortem, handling the body and washing the sponges during the dissection. He had no wound or abrasion upon his hands. On the evening of the third day afterward he had a shivering fit, and the next day, when admitted to the hospital, he complained of acute

pain in the right axilla and shoulder, with tenderness on pressure over the trapezius and pectoral muscles. He was feverish, with a pulse of 86, a moist, foul tongue, a pale and anxious countenance, and he was strongly impressed with the idea that he was the victim of a fatal infection. In fact, his case progressed very much as the last, and he died on the ninth day with similar symptoms.

The body was examined forty-eight hours later, and no evidences of local disease discovered until the *latissimus-dorsi* muscle was raised from its attachments, when the connective tissue beneath was found infiltrated with thick purulent matter, and beneath the *serratus magnus* quite a large purulent deposit. On dividing the ribs, the pleural cavities were both found to contain a large amount of sero-purulent fluid, and flakes of easily detached exudation could be scraped from the free surfaces of the pericardium. In the abdomen the intestines were found agglutinated by a thin cobweb-like film of exudation.

These cases, and there were others of the same character, show the quality to which the term *malignity* is applicable. If the thermometer had been used, a high temperature would doubtless have been found, and the lungs, spleen, muscular tissue, and blood would have shown the changes we now recognize as the results produced by blood-poison and consequent excessive and sustained high temperature of the body.

Travers, who has described an epidemic of this form of erysipelas, estimates the proportion of recoveries as low as only one in seven—a mortality of eighty-six per cent.

Thus, while the mortality of simple cutaneous erysipelas has been approximately estimated at from five to eight per cent, and the mortality of phlegmonous erysipelas at twenty-seven per cent, that of the malignant form of the disease has reached the enormous figure of eighty-six per cent.

The outline of treatment already laid down for septicæmia includes all that can be said under this head concerning malignant erysipelas, even more stress, if possible, being laid on *prevention;* for it is, beyond a doubt—like typhoid fever and hospital gangrene—one of the preventable maladies. In fact, the improved sanitary precautions available, and more or less in force at the present day, have certainly rendered this form of disease less frequent than formerly, so that we draw the best illustrations of it from the records of the past. Nevertheless, we have the seeds of the disease always around us, ready to germinate in a congenial soil; and, without constant watchfulness, outbreaks are still of possible occurrence in hospitals, asylums, and prisons.

Not to leave this important subject incomplete, I must remind you that erysipelas has also made its appearance occasionally as an *epidemic*, traversing large sections of country uninfluenced by climate or local conditions, and manifesting novel features which serve still further to illustrate the nature of the disease. I have been able to find no satisfactory records of epidemics of erysipelas which have occurred in Europe,* although the fact that it has so prevailed is referred to by all writers on the subject.†

* A report on this subject to the French Academy of Medicine, which had offered a prize for the best essay on epidemic erysipelas, written in 1866 by the Baron H. Larrey, makes it evident that the distinction between *epidemics* of the disease and its occasional endemic outbreaks was not clearly appreciated by the writers of the essays. The question of infection, which at that recent date was still apparently unsettled in France, seems to occupy the first place in the minds of all. Thus, Baron L. remarks at p. 18: "La contagion de l'érysipèle, généralement admise en Angleterre, mais longtemps niée en France, compte aujourd'hui parmis nous de nombreux partisans." One of the authors whom he is reviewing arrays much evidence in favor of contagion drawn from cases occurring during the *endemic* prevalence of erysipelas in certain localities, which both the writer and reviewer speak of as *epidemics* of the disease. "Rapport sur l'érysipèle épidémique lu à l'académie impériale de médecine," 620, Novembre, 1866.

† The peculiar feature of epidemic erysipelas as noticed in our coun-

But in our country, in the years 1841, '42, and '43, there was an undoubted epidemic, which swept extensively over different portions of it from Kentucky to northern New England, known popularly as the "black tongue" and "swelled head," and recognized by the profession everywhere as erysipelas.* The disease seems to have traveled very much as cholera does; it was recognized as contagious. "When once the disease entered a family, it generally passed through it." Very young children for the most part escaped with slight tenderness and swelling of the lymphatic glands about the throat, the aged and weak being affected most severely, and with high, but not excessive, mortality.

The outbreak of the erysipelas first upon the mucous membrane of the mouth and throat was the characteristic of this epidemic, but the disease occasionally occurred in its other forms; "diffuse cellular inflammation" prevailed coincidently, and, let it be remarked, so also did puerperal fever. At Lancaster, N. H., several cases of erysipelas, says Dr. Hall, occurred early in the autumn of 1841. Among these was that of Mr. H., residing at the extreme easterly part of the township, and secluded from the inhabitants around him by a dense body of forest two miles in extent. He was attacked by violent and deep-seated pain in the palm of the left hand, from which a few days before he had

try is the invasion, primarily, of the mucous membranes, and, by preference, that of the throat and nose, as though a poison conveyed by the air first came in contact with these parts. Its mortality was estimated at about twenty-five per cent. It was evidently a true erysipelas, and presented all the characteristic symptoms of the disease.

* "Remarks on an Epidemic Erysipelas, known by the Popular Name of 'Black Tongue,' which recently prevailed in Ripley and Dearborn Counties, Indiana," by George Sutton, M. D., of Aurora, Ind. "Western Lancet," November, 1843. The same epidemic has been described by Drs. Charles Hall and George I. Dexter, in the "Am. Jour. of the Med. Sciences"; by Dr. John Bell, of Philadelphia, in the American edition of "Nunnelly on Erysipelas"; and by Dr. J. A. Allen, "Boston Med. and Surg. Jour.," Nos. 2, 4, and 7, 1844.

rubbed a piece of skin. The hand and wrist were much swollen, and a deep erythematous blush extended along the inside of the fore-arm to the elbow; the glands in the axilla were also tender and enlarged. It was regarded as a case of phlegmonous erysipelas. After the lapse of a few days the whole hand and fore-arm became one extensive abscess, and was opened at several points, discharging a semi-putrid, watery sanies, very offensive to the smell.

While in attendance upon this case the physician was called to a Mrs. C., in labor with her first child, a fine, healthy, well-formed woman. The labor was natural, and she was left with every prospect of speedy convalescence. She was confined in the evening. Earlier in the same day Mr. H. had been visited, his hand and arm dressed, and a portion of dead connective tissue cut away which was protruding from a lancet opening. Mrs. C., on the third day after her confinement, was seized with all the symptoms of puerperal peritonitis, and, after a period of acute suffering, died on the eleventh day after the birth of her child.

During the prevalence of the epidemic in other localities, puerperal fever is mentioned as having been unusually frequent and fatal.

Although it is not certain that you will ever encounter it, *hospital gangrene* is a disease that should be mentioned in this connection. It is a consequence of over-crowding, and defective hygiene, and has disappeared wherever Listerism has been systematically practiced. This circumstance, its well-known infectious nature, and the additional fact that it prevails endemically, demonstrate that this disease is caused by a poison, and, since it is successfully counteracted by carbolic acid, by an organic poison.

More than twenty-five years ago it broke out at the old City Hospital in Broadway and continued all winter, and, being in active service at the time, I had

ample opportunity to study it. It also prevailed, under the exigencies of the service, in several military hospitals during our late war, but rarely presented the features of virulence recorded by writers of the last generation.

Hospital gangrene attacks open wounds and ulcers; its invasion is marked by a peculiar burning pain, and coincidently the granulating surface is converted into a grayish, pulpy slough, which tends to advance slowly both in depth and on the surface. It is certainly conveyed from one patient to another by sponges, instruments, and dressings, as vehicles of the poison.

The remedy which I found most reliable in arresting the disease was pure nitric acid applied carefully but liberally enough to saturate the slougy surface, including the margins of the wound. This application effectually arrests the peculiar pain, as well as the progress of the disease, until the eschar formed by it has separated. If the tendency to slough has been permanently checked, healthy granulations resume their growth; on the other hand, if the disease return—and this will probably happen if the patient has not been isolated—its recurrence will be indicated by a return of the characteristic burning pain. I found that systematic repetition of the caustic greatly economized the destruction of tissue, and, with isolation, effectually arrested the disease.

In its severer forms the advance of the gangrene is more rapid; blood-vessels of size may be invaded, and life seriously endangered. We read of these in Hennen's experience of Wellington's Peninsular campaigns. Before the introduction of antiseptics, the stronger caustics or the actual cautery, with new surroundings and care in hygiene, were the only remedies.

According to Nussbaum, of Munich, hospital gangrene had prevailed continuously for three years in the wards of his hospital, interfering greatly with the success of surgical operations, most cases of which were

attacked by it; but, as soon as the practice of Listerism was adopted and faithfully carried out, the disease ceased to attack wounds, and finally disappeared.

I am disposed to believe that hospital gangrene is a *preventable* disease, and will ultimately become extinct.

Acute phagedæna, which occasionally attacks venereal ulcers in hospital practice, presents a close resemblance to hospital gangrene. It is characterized by similar burning pain, but in a less degree, and is amenable to the same remedy; but it is not certainly infectious.

Glanders, or farcy, a contagious disease of the horse, dependent upon a peculiar virus or poison, is certainly also communicable to man. The discharge from the nostrils of a diseased horse brought in contact with an abraded surface or a mucous membrane will communicate the disease. It takes the form of a low malignant fever with nasal discharge and pustules of the face, and is generally fatal. These were the prominent features of a case I saw in Charity Hospital, on the Island, in 1875. Its treatment is entirely preventive, for there is no known remedy.

CHAPTER XX.

Hydrophobia.

THERE is another animal virus of peculiar and fatal power, which originates in the dog and in animals of the dog kind, causing the disease known as *canine madness*, or *rabies*. Although never originating elsewhere than in the dog and his congeners, the wolf, fox, and jackal, the virus of rabies is capable, unfortunately, *of being communicated to all warm-blooded animals.*

The virus of rabies is generated especially in the secretions of the mouth and throat, and is almost invariably transmitted by the saliva of the rabid animal; but the blood and the secretions of an affected animal, its flesh and viscera, even the cooked flesh of a rabid ox, when eaten, would seem to be capable of conveying the disease. A pupil at the veterinary school of Copenhagen inoculated himself with the virus by cutting his finger slightly while examining the body of a dog that had died—mad—on the evening before; the student died of hydrophobia in six weeks. (Hertwig, "Jahrsbuch," 1859, p. 60.)

The name *hydrophobia* is applied to the disease which develops itself in man after inoculation from a rabid dog, because a peculiar dread of fluids is the most characteristic symptom of this disease in the human being. This symptom, a dread of fluids, does not exist in the dog; it is wrong, therefore, to apply the name of hydrophobia to a disease that originates with and belongs especially to this animal. *Hence, in the*

dog we speak of the disease as rabies; in man, as hydrophobia. This use of the term hydrophobia, applied to the dog—implying, as it does, *a dread of water*—has, indeed, proved to be a source of danger; for, under the influence of this erroneous idea, if a dog suspected of being mad is offered water and laps it freely and frankly, he is at once acquitted of suspicion. But, in fact, the test is entirely fallacious, for a dog suffering from the poison of rabies will take water ravenously; and this very dog might be turned loose, by those ignorant of this peculiarity of the disease, to do fatal mischief.

A better test for the presence of rabies is to bring the suspected dog into contact with another dog, who, instead of going through the usual ceremonies which attend canine introduction, will slink away, betraying unmistakable and instinctive fear, even though he be a larger and fiercer animal, while the suspected dog will, almost invariably, manifest fierce excitement and a desire to attack other dogs at sight, even though previously quiet and entirely under the control of his master's voice and influence.

This terrible disease is invariably fatal, both in the dog and man; there is no authentic instance or record of recovery from genuine hydrophobia. We are in possession of no remedies which offer any rational chance of saving the life of a human being attacked by it. As it never originates in man, but comes to us by inoculation from the dog, *our only safety lies in recognizing its presence in the dog at the earliest possible moment, and in taking measures to protect ourselves, and the warm-blooded animals in our service, from the great danger of inoculation.* Every peculiar feature of the disease, therefore, by which we may be enabled to recognize it early in the dog is of the greatest value to us; and it is manifestly our duty to study the disease in the dog first and foremost, since of its symptoms in man we require, at present, no more

knowledge than is necessary for diagnosis; as for treatment we are powerless. We do not proceed to smother the victim, as is said to have been ordained by law in some communities, but we are compelled to recognize that its rapid and fatal termination is inexorably sure.

Now, this *grave error, that a dog who will lap water or milk when set before him can not be mad is very prevalent*, both popularly and in the profession, and no doubt many a life has been sacrificed because a suspected dog has undergone this supposed test favorably. I am justified, therefore, in citing the opinion of Fleming on this point, who is an acknowledged authority in England, having been employed by the government as an expert. He says that "the many hundreds of rabid dogs seen by Blaine, Youatt, and others, did *not evince any marked aversion to fluids.* On the contrary, the rabid animal is generally thirsty, and if water be offered will lap it up with avidity, and, at the commencement of the disease, will always swallow it. When, at a later period, the constriction about the throat, which is symptomatic of the malady, renders swallowing difficult, the animal does not the less endeavor to drink, and the lappings are as frequent and prolonged as deglutition is retarded. Even then we see the suffering creature in despair plunge its entire muzzle into the vessel and gulp at the water as if determined to overcome the spasmodic closure of the throat by forcing down the fluid. Tantalus could not experience a greater torment with regard to water than does the unlucky dog."* You will understand, therefore, why I say that it is unfortunate that the name hydrophobia has been applied to the disease, since in the dog the fear of water does not exist.

There is another marked difference in symptoms between rabies in the dog and hydrophobia in man: the latter is characterized by excessive sensibility to

Fleming, "Rabies and Hydrophobia, their History, Nature," etc., London, 1872, p. 141.

pain; the slightest touch or noise, a change of temperature in the apartment, the sound of running water, the contact even of a current of air as produced by a fan, or even, it is said, the reflection of bright light from a looking-glass, will bring on spasm attended by the most acute suffering. Druitt says that in July, 1854, he saw a case of a middle-aged woman who had been bitten in the foot by a cat in the month of April preceding. She was lying in bed rational and tranquil, and nobody could have seen at the first glance that she ailed much. He "took her hand to feel her pulse, and, while doing so, breathed on it as gently as possible. Instantly the poor woman started up in bed, choking with spasm in the throat. This was sufficient for diagnosis." It was certainly a more gentle and merciful proceeding than offering the patient a glass of water, which is the usual mode of bringing out the pathognomonic symptom.

The rabid dog, on the contrary, is almost insensible to pain; he will dash himself against the bars of his kennel, tear them when his mouth is lacerated and bleeding—even when his jaw is broken—and he has been known to seize a red-hot poker in his mouth and hold on to it, apparently unconscious of suffering.

Thus, while the virus, and the disease to which it gives rise, are the same, it is, nevertheless, liable to be attended by very different manifestations when communicated to other animals, according to their race and habits.

There are so many exaggerated stories current concerning this terrible disease, which seems to have been known as far back as the history of our race extends, that it behooves us, as men of science, to inform ourselves accurately concerning it. My time will permit me to do little more than to lay before you the symptoms by which it may be recognized in the dog, and in man; and then I must refer you to your text-books, and, still better, to two excellent monographs—one by

Fleming, which I have quoted, the other by Bouley, who is at the head of veterinary science in France. The latter monograph, which contains the results of extensive investigations made by the French Government, has been translated by one of our best veterinary surgeons, Dr. Liautard, of this city. Professor Dalton also has an excellent article on the subject in "Appletons' Cyclopædia."

To counteract the dread always inspired in the popular mind by the idea of hydrophobia, it is well *to keep in view the fact of the extreme infrequency of the disease.* In the Department of the Seine, in France, which includes Paris, with an average population of over a million, during forty years there were ninety-four cases of hydrophobia, or a little more than two and a third per million. In New York, with about the same population, in the six years from 1866 to 1871, inclusive, there were twenty-two cases, or an average of three and two thirds. (Dalton, *ut supra.*)

The early symptoms of madness in the dog are very significant, and should be known by every one, for upon securing their prompt recognition, more than upon dog laws, or muzzles, or medical skill, depends our ability to protect and save human life. Distrust, says Bouley, a dog when it commences to be unwell; every sick dog should, as a rule, be suspected, tied up, and watched. More particularly distrust a dog when the animal becomes dull, morose, mopes, and seeks for solitude; when he appears not to know where to rest; when he is always on the move, prowling, snapping at the air, and suddenly barking at nothing, when there is no cause for excitement. Beware of the dog that seeks and scrapes incessantly, and exhibits aggressive movements against phantoms; and, finally, beware, above all, of the dog which has become too fond of you and is continually endeavoring to lick the hands or face.

The duration of the disease in the dog never exceeds ten days, and in the majority of cases the animal dies

on the fourth, fifth, or sixth day after the appearance of the first symptoms. During the first two or three days of the disease, although the saliva, or foam, about the dog's mouth is virulent, there is rarely any tendency on the part of the animal to bite, nor to paroxysms of ungovernable fury. He manifests the symptoms which have just been described. The danger in this stage comes from licking rather than biting, for there is a propensity to unusual demonstrations of affection. Some years ago, says Lawrence, a lady of rank and fashion had a pimple on her face of which she had scratched off the head. She had a lap-dog which she allowed to lick her face. Hydrophobia was thus contracted, and she perished by this terrible disease.*

After a time, however, a paroxysm of maniacal fury comes on, generally provoked by the sight of another dog. When this has subsided, the animal is again influenced by his master's voice and authority, but manifests a singular disposition to leave home and wander away to strange parts, as though he knew instinctively that he might harm those he loved. He is now most dangerous. With a slinking and troubled aspect, his head down, his eyes injected, and foam at his mouth, he goes on his way, snapping and biting at everything that crosses his path. He is not, as a rule, distinctly aggressive except when directly attacked, and then his fury seems unbounded. When exhausted, he drops in some out-of-the-way corner, and, after a rest, starts off again on his melancholy raid, seemingly impelled by some irresistible force; and he wanders in this aimless way until he is killed, or dies utterly worn out.

The best authorities hesitate to admit the spontaneous outbreak of the disease in the dog, believing that it can be almost invariably traced to inoculation from another rabid animal. The irregular and uncertain period of incubation of the virus, both in the dog and in man, throws obscurity about this question. As to

* "Lectures on Surgery," London, 1863, p. 261.

the *period of incubation in the dog*, no reliable duration can be stated; it is usually from six to twelve weeks, but may extend to a much longer period. An authority quoted by Bouley (Frank), in two hundred observed cases of rabies in the dog found that the average period of incubation was three months; the extremes, six and seven days, and eleven months. With other animals the period also varies. In young animals the disease develops sooner, and this holds good in man. In one hundred and six cases of hydrophobia in human beings at all ages, collected by Bouley, twenty-three occurred within two months after being bitten, and the remainder came in at varying periods, dragging along up to the eighth month. *After a year has elapsed there is freedom from danger; and, in Fleming's opinion, after the eighth month.* In patients under twenty years of age the mean period of incubation was six weeks; from twenty up to seventy-two it was two months and a half.

There is one gratifying feature brought to light by the study of this fearful disease, namely, that *about one third of the animals and human beings bitten by mad dogs escape all danger.* This percentage of immunity, which is well established, is explained in part by the virus being diluted, and by its being wiped from the teeth of the rabid animal by clothing; and also by well-ascertained facts proving *absence of susceptibility to its action in certain individuals*, both in animals and in man. Renault's careful experiments, quoted by Fleming, proved that one fourth of the inoculated creatures escaped the effects of the inoculations, which were mortal in the other three fourths. What better instance can we have, he adds, than that of the mastiff which Hering unsuccessfully inoculated many times during three years, while other dogs experimented upon at the same periods and with the same virus developed rabies? This predisposition, or susceptibility, is more conspicuous, generally speaking, in the canine or feline species than

in the herbivora or in man. Dogs and cats hold the first place in the scale of susceptibility; then man and the pig; next ruminants—the sheep and goat being more susceptible than the ox; and, lastly, the horse. (Fleming, *op. cit.*, p. 148.) Statistics show that children between five and fifteen are more liable to be bitten, and also that they are more likely to escape the effects of the poison, the proportion of those developing the disease being still lower than the average.

Before the development of the disease in man there is always a period of a few days during which *premonitory symptoms* may be detected; itching, uneasiness, and sometimes pain at the seat of the bite, and the latter may extend along the nerves of a limb; with this the patient is depressed and irritable; light is offensive to him; he prefers solitude, sleeps badly, and is full of aches and pains.

In the dog the premonitory uneasiness at the seat of the bite, where there has been, usually, a cicatrix to all appearance perfectly healthy, induces the animal to rub and even to gnaw the part until it becomes irritated, and, in some cases, raw. This characteristic premonitory symptom is the basis of Brown-Séquard's opinion "that an alteration takes place in the part of the body that has been bitten by a rabid dog before the convulsive and other phenomena of hydrophobia appear; and also that the convulsions of hydrophobia occur by fits following a kind of *aura* starting from the cicatrix of the bite. He admits that there is a poisonous principle in the saliva of rabid individuals; but he thinks that it is in consequence of changes produced locally in the nerves wounded by the bite that the phenomena of the fully developed disease occur. He relates a case communicated to him by Dr. Stokes, of Dublin, in which the convulsive paroxysms seemed to have been distinctly arrested by the application of a tourniquet to a limb. *

* "Lectures on the Central Nervous System," p. 261.

The first actual symptom of hydrophobia in man is a sense of tightness and choking about the throat, attended by a hesitation in swallowing, especially of liquids. "The difficulty in swallowing rapidly increases, and it is not long before the act becomes impossible, unless it is attempted with determination, though even then it excites *the most painful spasms in the back of the throat, with other indescribable sensations*, all of which appal the patient and cause him to dread the very thought of liquids. Singular nervous paroxysms or tremblings become manifest, and sensations of stricture and oppression are felt about the throat and chest. The breathing is painful and embarrassed, and interrupted with frequent sighs, or a peculiar kind of sobbing movement, or catching of the breath; there is a sensation of impending suffocation and of necessity for fresh air. Indeed, the most marked symptoms consist in a horribly violent convulsion or spasm of the muscles of the larynx and pharynx or gullet, by which swallowing is prevented, and at the same time the entrance of air into the windpipe is greatly retarded. As Fleming describes it, shuddering tremors, sometimes amounting to general convulsions, run through the whole frame, and a fearful expression of anxiety, terror, and despair is depicted on the countenance." There are hallucinations of sight and of hearing. One patient alluded to by Trousseau heard the ringing of bells and saw mice run about on his bed. There is a copious secretion of a viscid, tenacious mucus in the fauces—the "hydrophobic slaver"; this the patient spits out with a sort of vehemence and rapidity upon everything around him, as if the idea of swallowing occasioned by the presence of the liquid induced this eager expulsion of it lest a drop might pass down the throat. This, to a bystander, is sometimes one of the most striking phenomena of the case. In the last hours preceding dissolution the patient's mouth is often full of this mucus, or froth, which is in some cases

tinged with blood. The lower jaw would appear to be sometimes partially paralyzed, and then the saliva flows from the corners of the mouth. The temperature of the body, which has been found as high as 106·2° in the rectum immediately after death, proves the intensity of the chemical changes which are taking place in the body. Death occurs from complete exhaustion, in most cases attended by well-marked evidences of asphyxia from spasm of the glottis; sometimes a convulsion is the final symptom, as in tetanus.

In ninety cases collected by Professor Bouley, death occurred in seventy-four during the first four days, the largest proportion of these being on the second and third days. In only sixteen cases was life prolonged beyond the fourth day.

The morbid appearances found after death by hydrophobia, as in all cases where a poison kills by its action upon the nervous centers, are mostly negative and unsatisfactory. According to Bollinger, the anatomical picture bears the strongest resemblance to that seen in cases of death from asphyxia or thirst. There are emaciation and rigor mortis; the blood is usually thick, tarry, black, and but slightly coagulated; there is hyperæmia and œdema of the substance of the brain, medulla oblongata and cord, and of their membranes; deep-red injection of the mucous membrane of the pharynx and epiglottis, and sometimes recent swelling of the tonsils, follicular glands of the tongue, pharyngeal follicles, and of the lymphatic glands in the neighborhood of the jaw. The stomach and intestines show decided injection, and often hæmorrhagic erosions. The lungs are charged with blood, with frequent spots of hæmorrhagic effusion, and sometimes emphysema—as a result of the dyspnœa. The trachea and larynx are congested, and there is often bloody froth in the bronchi.*

Klebs found general lymphatic engorgement in a

* Bollinger in Ziemssen's "Cyc. Prac. Med.," vol. iii, p. 495.

recent case, and *discovered, particularly in the sub-maxillary gland, "deposit of finely granular, strongly refractive corpuscles of a faint brownish color, closely packed together in clusters and rows," which he regards as "possibly the vehicles for the transfer of the specific infecting material."* *

There is one post-mortem feature very often present *in the dog* which is noticed by all observers, and is really more characteristic of rabies than any of the purely anatomical appearances; this is the presence of foreign substances in the stomach which have been bolted by the demented animal for food, such as bits of wood, straw, gravel-stones, even fragments of glass, and masses of excrement. Fleming remarks that *the presence of any considerable quantity of ordinary healthy food undergoing digestion in the stomach of a suspected dog would be to him excellent evidence that the dog was not mad.*"

As regards *diagnosis*, the important symptoms of hydrophobia are referable to the nervous centers, mainly the medulla oblongata—e. g., the severe spasms of the muscles of respiration and deglutition, and the increased reflex excitability. (Bottingen, *ut supra.*)

There is a certain resemblance to *hysteria* in hydrophobia, particularly in the distress about the throat, and the sense of suffocation, which in both diseases is worse by paroxysms. The convulsive character of these paroxysms also strongly recalls those of *tetanus.* But the jaws are not persistently and spasmodically closed in hydrophobia; on the contrary, they are in constant motion in spitting and talking excitedly. The rapid progress and early termination of hydrophobia distinguish it from hysteria.

There is a condition of excessive nervousness, made up principally of dread of the disease. This condition sometimes develops itself in timid and excitable per-

* "Sitzungsbericht des Vereines deutscher Aerzte in Prag. Aerztliches corresp. Blatt für Bohmen," 1874, ii.

sons. Trousseau speaks of it as "mental hydrophobia," and it has no doubt passed for the real disease. Fayrer describes a case of this kind in a young Scotch engineer in India, and Bollinger quotes a case of a boy who was twice frightened into simulated hydrophobia.

The *treatment* of hydrophobia consists in surrounding the patient by absolute quiet in a darkened chamber, and securing the services of trained nurses. Nutritious enemata, with the addition of the bromide of sodium and chloral, may possibly be of service.* The subcutaneous injection of morphia at proper intervals is the remedy of greatest value in diminishing the patient's terrible suffering and securing a less agonizing death. As in delirium tremens, which, in the feature of watchfulness, resembles hydrophobia, *there is extreme tolerance of narcotics, and morphine should therefore be administered in full doses.* The infallible remedies always put forward in the hope of profit by the ignorant and greedy may have had occasional success in the simulated or hysterical form of the disease, but they have failed invariably in the genuine malady. Sweating by hot fumigations or steam has proved equally useless.

According to Bollinger, Magendie injected two pints of water into the veins, producing an immediate quieting effect, a reduction of the pulse from 150 to 86, and a return of the ability to drink; but death followed. Gaspard also tried this treatment, with similar result. Transfusion of blood remains to be tried.

With this impotence as to remedial measures, are there any preventive means worthy of our confidence? What is the surgeon's duty in a case of a recent dog-bite from a suspected animal? First and foremost the dog should be secured and safely confined, in order to ascertain, certainly, whether or not he is mad. The

* For evidence in favor of chloral, see Mr. Ellis's cases in London "Lancet," Aug. 12, 1871, and "Brit. Med. Jour." for Dec. 2, 1871—three cases.

common course of killing a dog at once who has bitten any one is not wise; for the wounded party is thereby left in a state of painful uncertainty, which might be avoided by watching the animal for a day or two. In a given case the chances, of course, are against the probabilities of a dog being affected with rabies; when this becomes a certainty, all apprehension ceases. If the dog should prove to be really mad, the patient has still his thirty-three chances out of a hundred of escape from hydrophobia.

How should a recent wound be treated? Should it be cut out? Should it be cauterized? I would advise that both of these measures be adopted, and with the least possible delay; and, besides, that a tourniquet or ligature be at once thrown around the limb, if this be the seat of the injury, to arrest the passage of the poison into the circulation; and that the patient be made to suck the wound vigorously with his mouth while preparations are being made for its excision. If the location will permit, the following is the most surgical mode of effecting excision: Introduce a straight needle, armed with fine silver wire, alongside of the wound, being careful to carry it more deeply than the dog's tooth has penetrated, and bring it out at the same distance on the other side of the wound; then, drawing on the two ends of the wire, proceed to cut out all the tissues included in its loop by means of two elliptical incisions. Promote the flow of blood by warm fomentations or by suction, and, as soon as it begins to cease, cauterize the whole raw surface thoroughly with the actual cautery.

This may seem like severe treatment, especially if applied to every case of bite of a suspected animal; but the dreadful alternative is to be kept in view, and the utter inefficiency of all other remedies; and, if done at all, it should be well done. The authority for this practice is to be found in the fact *that of one hundred and thirty-four collected cases in which bites of mad*

dogs were cauterized, sixty-eight escaped and forty-two died—a degree of immunity far above the average, which, as I have already stated, is thirty-three per cent. (Bouley.)

It is a popular error that madness in dogs occurs only in the hot months; it is liable to take place at any season, in isolated cases, *or as an epizootic; and of the epidemic prevalence of hydrophobia there are frequent examples.*

With the account of this most virulent and deadly of the poisons, the effects of which are liable to be encountered by the surgeon, I shall end this part of the course, adding only the following remarks, which I may be able more fully to exemplify hereafter. The subject of poisons has of late attained a degree of practical interest never before accorded to it—mainly because new poisons have been demonstrated to be the causes of diseases of which the pathology has been heretofore unknown, and because antidotal remedies for some of these diseases have been found to possess curative power.

Moreover, positive and important advances have been made in our knowledge of the nature of these poisons, promising a further extension of our power of preventing and curing the diseases to which they give rise.

Again, the presence of poison in contact with our tissues, while proved to be competent under certain circumstances to destroy textural life, when this end is not reached, tend for the most part to excite cell proliferation—in the tissue-cells. This is seen not only in connective tissue, but in the epithelium of mucous and serous membranes and in the endothelium of blood-vessels.

This proliferation of tissue-cells, whereby the tissue tends to return to its embryonic state, constitutes the histological change which is now regarded as the essential feature of the condition which we call inflamma-

tion. Poisons are, therefore, correctly regarded as inflammation producers; and, as far as the nature of the poisons is septic, which is mostly the case, their remedies have come to be known as antiseptics; and it is thus explained why the term antiphlogistic has gone out of use in a degree, and has been replaced by the newer term antiseptic.

CHAPTER XXI.

Gangrene.

I HAVE spoken to you of inflammation, stating that, in my opinion, it is *not a disease*, but that it is more properly spoken of as a *condition*, which consists in a derangement of the nutritive machinery of a part, characterized in most cases by pain, heat, redness, and swelling, with suspended function. That this condition is produced by certain causes—e. g., mechanical or chemical violence to the living tissues, and the action upon them of poisons. *The best modern definitions* of inflammation are in accordance with this view. Inflammation, says Burdon-Sanderson, is the name given to the series of changes which follow injury to a living part, provided the injury has not been so extreme as to deprive the part at once of life. With this the best French pathologists—Cornil and Ranvier—agree.

The purpose and object of the inflammatory condition is, for the most part, the repair of injury. When this object constitutes the limit of the series of changes, it is spoken of as the *process of repair*, or as *constructive inflammation*. When, on the other hand, either suppuration, ulceration, or local death takes place, it is because the natural reparative power with which our organisms are endowed are unequal to the task imposed upon it; that the local nutritive machinery is unable to antagonize and remedy the effects of injury to the tissues; and therefore repair is either delayed or it becomes impossible, *and the part dies.* To these latter changes the term *destructive* inflammation is conveniently applied.

We have already studied the details of the mechanism of the process of repair in connection with the several modes by which wounds heal. Incidentally, we have examined the phenomena of ulceration and suppuration, and inquired into the nature and uses of pus; but the details pertaining to the death of tissue yet remain to be considered. Several of these groups of phenomena are habitually spoken of, by those who treat of inflammation as a disease, as *terminations of inflammation.*

I scarcely need to tell you that this phrase has lost any exact meaning, and is not, with our present knowledge, scientifically correct. The condition of inflammation, strictly speaking, can end only in two ways, namely, by *resolution*, which means a disappearance of all its physical signs and a return to health in the part, or by local death or gangrene.

The subject of *gangrene* requires, therefore, separate study, and should claim attention here. We have already encountered the process of *ulceration*, which I described to you as local death of tissue in detail—by minute particles—a molecular gangrene, which occurs as an incident in the pus-producing phase of inflammation. Now we have to deal with death of tissues in *visible masses. The term gangrene means local death —i. e., death of a part of the body, in contradistinction to the whole; its synonyms are mortification and sphacelus.*

The most frequent *cause of gangrene* is mechanical violence by which the life of a part is directly or indirectly destroyed: as when a limb is crushed by an overwhelming force, or its main artery so injured as to impair its function. But a limb may fall into gangrene without the intervention of external traumatism, when, for example, its vascular supply has been cut off by disease, as in that variety of the affection known as *senile* gangrene. Hence gangrene is spoken of as *traumatic* and *spontaneous*. The first includes by far the larger

proportion of cases as they occur in practice; the latter term, which is not strictly accurate, is used for convenience to include all cases in which the more immediate cause of the local death is not clearly apparent.

Another division is into *moist* and *dry* gangrene. This is based upon the presence or absence of the more ordinary signs of putrefaction in the dead parts, such as softening, melting away by liquefaction, with the characteristic cadaveric odor. Where the fluids are gradually withheld from a part, or when it is deprived of its arterial blood by degrees—as when the arteries are constricted by the habitual use of ergot, the tissues that die simply shrink, turn dark-brown in color, in rare instances grayish white, and become mummified, as it were, and odorless, remaining subsequently entirely unchanged. *I have seen this happen in several instances during convalescence from typhus fever, where it was caused entirely by extreme poverty of the blood and feeble action of the heart.*

To whatever cause gangrene, whether traumatic or spontaneous, may seem to be attributable, the real reason why the part dies will be found, almost invariably, in the fact that its blood-supply has been in some way diminished or entirely cut off. In addition to the cases mentioned, we have examples of this in the occasional instances of gangrene of a limb after ligature of its main arterial trunk for the cure of aneurism, where the collateral circulation has, for some reason, proved insufficient; in gangrene from embolism as a consequence of heart-clot, or from arterial disease, as in senile gangrene, and in other varieties yet to be mentioned.

Can we logically or accurately speak of gangrene, in any of its aspects, as a termination of inflammation? When an injury is severe enough to threaten the life of a part, there is always an interval of time between the reception of the injury and the appearance of the signs of gangrene. During this interval there may be an ineffectual effort at repair, and the afflux of blood and

disturbance of the capillary circulation incident to this effort may even hasten the actual death of the injured tissues; but it would be hardly correct to ascribe the gangrene to the inflammation rather than to the injury; nor yet to speak of it as a "termination" of inflammation which, like some cruel disease, had attacked the part. By the mechanism by which repair is usually accomplished, by the overtasked local nutritive machinery, doubtless, tissue is not infrequently deprived of life. We have an example of it in the gangrene that sometimes follows punctures made to relieve excessive dropsical swelling of the legs. The little wounds become surrounded by livid discoloration, and the local death extends by progressively invading the integument. Here the blood-vessels of the skin are already very much stretched by the fluid collected in the superficial fascia, and the nutrition of the integument is impaired in a corresponding degree. There is an immediate effort to repair the wound, but the afflux of blood to its margin, lacking sufficient cardiac impulse, stagnates at once, and the enfeebled tissue, unable to react under the stimulus of the effort, dies forthwith, in the stage of stasis, from entire stoppage of its nutritive supply. In this manner the gangrene extends until it reaches a portion of integument, the blood-vessels of which can correspond to the inflammatory effort, and then repair is begun, and a line of demarkation forms, in the shape of a margin of granulations. This is the mode in which gangrene advances when it invades living parts; and this I believe to be the true relation between inflammation and gangrene.

I once had under my care a patient with an enormous aneurism of the groin, on the summit of which a patch of integument as large as a silver dollar turned black and died. The dead patch constituted what we call an eschar. Previous to its formation the skin at this spot had been first red, through congestion; then livid, through stagnation of the blood in its capillaries.

The formation of this eschar might be regarded as a termination by gangrene of inflammation of the skin; but the more simple explanation of the phenomena is that they were all due to arrest of circulation in consequence of extreme stretching of the vessels at the summit of the aneurism by reason of its rapid growth.

The frequent occurrence of gangrene of the integument from stretching or interference with its nutritive vessels, by dropsy or other lesion of the subcutaneous connective layer, demands further illustration, because, under these circumstances, timely incision of the skin, by relieving the tension of its blood-vessels, may often save its life.

After simple erysipelas of the face, pus not uncommonly collects in the loose connective tissue of the upper eyelids, as we know, and this event demands prompt incision to save loss of substance by ulceration or slough.

In phlegmonous erysipelas the same necessity, as we have seen, is vastly more urgent. Extravasation of urine into the subcutaneous tissue causes its rapid death; and this is rendered palpable by emphysematous crackling under the fingers of the gas extricated from the dying and dead tissue. When this is felt, gangrene of the skin is imminent, because its nutrient vessels are also involved. But the blood-vessels are tenacious of life, and incisions may limit this gangrene if they are made very promptly and freely.

Whenever, under circumstances like these, the skin develops patches of gangrene, it may be assumed with certainty that the *subcutaneous* tissue is stricken with death, and that free openings are required for its elimination in a sloughy form; but it is good surgery to have anticipated and prevented the death of the skin by incisions.

The subcutaneous tissue, like the osseous tissue in adolescents, may be killed outright by sudden chilling, as in the following case which I saw with Dr. Arango.

An elderly gentleman had been sitting for some time, on a cold, windy day in January, in a very hot room; when, desiring to pass water, he went out around the corner of the house, and as he exposed his person, moist with perspiration, the cold north wind struck him with full force for some minutes. That evening he had a chill, and the next day the scrotum was swollen, tense, and painful. The day following there were several black patches on its surface where the skin had died, and by the fourth day the whole scrotum was black and gangrenous. Free incisions at this stage made it evident that the connective tissue of the scrotum was also dead, for little or no blood followed the knife, although it was very freely used. The patient was liberally supplied with quinine and milk-punch; the sloughs separated kindly, and at the end of a fortnight the testes—each, with its cord—were freely exposed and covered with healthy red granulations. They were properly supported upon a little pillow, the generous treatment steadily continued, and in six weeks this extensive loss of substance was entirely replaced by tissue of cicatrix. The new scrotum was limited in capacity, not pendulous, and it held the testicles snugly against the perinæum, like the scrotum of a dog; but its purpose was fully answered, and there was no occasion for complaint. The patient enjoyed good health for some years, and finally died of pneumonia.

In former days, when the radical operation for the cure of hydrocele consisted in the injection of a solution of sulphate of zinc or of port-wine into the cavity of the tunica vaginalis, a portion of the injection, in spite of every precaution, would occasionally find its way into the "cellular tissue," as it was then called, between the tunica vaginalis and the scrotal integument, and the inevitable result of this accident was sloughing of the scrotum. I remember a white-haired old gentleman of Brooklyn, whom I assisted the late Valentine Mott to operate upon some thirty-five years

ago, who, in consequence of this accident, went through the process I have just described. The whole scrotum sloughed, but the patient eventually recovered.

At present the tincture of iodine is preferred as an injection in hydrocele; it is not so poisonous in its effects upon the connective tissue; but even with this remedy I have witnessed occasional trouble, in a less degree, in elderly patients. The wonderful reparative energy displayed in the healing of these lesions of the genitals in advanced life is worthy of notice.

I have referred to these cases to show that gangrene of the skin is often due to *interruption of its vascular supply.* This is undoubtedly, of all the causes of gangrene under all circumstances, by far the most common, and, if *I were to multiply examples, they would demonstrate that lack of blood of proper quality, no matter how it is brought about, is the explanation, almost invariably, of local death.*

Compression, as we know, is capable of arresting the circulation in a part, and, when kept up long enough, will cause its death. This result occurs with unpleasant frequency from pressure of splints and bandages in the treatment of fracture. Sometimes a fragment of misplaced bone makes pressure upon the main artery of a limb; but, more frequently, swelling caused by the injury, coming on after the retentive dressings have been applied, so intensifies their pressure as to obstruct circulation. The pain that follows is ascribed to the fracture, and borne for this reason, with the aid of opium, until serious harm results in the form of local eschars, or possibly gangrene of the limb.

In a case of badly united fracture of the femur in its upper third, in a sailor at the New York Hospital, my colleague, Professor Post, cut down upon the bone and exsected a V-shaped portion. Afterward the limb was placed in a straight position, but it almost immediately fell into gangrene, and the patient died within a few days. It was found, on post-mortem examination

of the parts, that the upper fragment of the divided femur, dragged upon by the psoas and iliacus muscles, had effectually obstructed the circulation in the femoral artery by the forward pressure of its lower end.

Bed-sores illustrate the effect of local deprivation of blood in causing the formation of eschars. The weight of the body, borne by prominent portions of the skeleton, compresses the soft parts against the bed, and the compression is often aided by the feebleness resulting from local paralysis or other disease and want of cleanliness. Hence the prominence of the sacrum is the most frequent seat of bed-sores, and death has actually followed from opening of the spinal canal. I have seen dry eschars, after typhus fever, upon the spines of the scapulæ, the borders of the ears, the calves and the heels—in fact, wherever the body habitually touched the bed.

The first local symptom in an ordinary bed-sore is congestive redness of the skin, followed by the formation of little blisters and then an eschar, so that there is usually an inflammatory element present, provoked by local contact of acrid materials with the enfeebled skin.

The preventive remedies against bed-sores are frequent changes of position of the body when feasible, scrupulous cleanliness, daily bathing with alum dissolved in alcohol, or spirits, to harden the skin, and a water-bed to equalize pressure. Afterward, contrivances to obviate local pressure, such as nests of prepared oakum, or rings cut out of adhesive plaster, with dressings of balsam of Peru, or resin ointment.

Among other and less common examples of gangrene I may mention local softening of the brain from embolism of the cerebral arteries, a condition formerly ascribed to inflammation. I once tied the primitive carotid artery in a patient in the adjoining hospital for a malignant growth in the nostrils. Death followed in a few days, preceded by hemiplegia; and the corpus

striatum of one side was found almost diffluent from softening. There was in this case, as we found on post-mortem examination, an anomaly of the circle of Willis and defective anastomosis, so that the operation had seriously interfered with the supply of blood to the brain.

Gangrene of the lung, also, is sometimes caused by embolism of the pulmonary artery. The pressure of the child's head in prolonged labor; the strangulation of a knuckle of intestine in hernia; the constriction of the penis by a ring, or a ligature—are examples of local death from interrupted circulation.

A blister applied to the chest of a child after measles has been known to cause the skin to slough. Here the poverty of blood caused by the poison of the eruptive fever renders the skin unable to resist the action of the poison of the cantharides as applied locally. The vulva is sometimes attacked by gangrene, and it occurs also in the cheek in children, under the name of *noma*—from a similar cause—poverty of blood from defective nutrition. I have frequently seen gangrene of the feet and of the fingers from cold, as well as from starvation. This was common in the feet of the soldiers, from standing in the wet and cold trenches, at the siege of Sebastopol.

Mercurial poisoning will cause sloughing of the mouth; and the local influence of certain septic poisons in causing mortification, as in hospital gangrene, is already familiar to you.

In collecting cases with the object of determining the causes of death after ligature of the great arteries, I have found that gangrene of some portion of the upper extremity has followed ligature of the subclavian artery in its outer third in nine per cent of the cases operated on; of the external iliac, in over fifteen per cent; and of the femoral in more than eleven per cent.

I have noticed, especially, that the chances of gangrene are greater when, in addition to cutting off the

direct supply of blood to a limb, the quality of the blood in the limb is already deteriorated. This is illustrated in a case of much interest, which I have reported elsewhere,* of a gentleman in whom the late Valentine Mott tied the external iliac artery for an *arterio-venous* aneurism near the groin. There was in this case a direct intercommunication between the femoral artery and vein, the result of a gunshot wound, so that the arterial blood was returned in a large proportion directly to the heart, and the less pure venous blood was distributed to the limb through the artery as its only source of nourishment. As a consequence of this condition of the circulation, the whole limb fell into gangrene as soon as its main artery was tied. It will serve our present purpose to recall the *symptoms* in this case, which I noted carefully at the time. On December 16, 1846, a ligature was applied to the external iliac artery by Mott, with the immediate effect of stopping all pulsation in the tumor, and causing, at the same moment, a sensation of numbness in the limb. The temperature of the limb soon became sensibly lower than that of its fellow, and it continued to fall, so that at the end of an hour the surface of the limb was distinctly cold to the touch. Six hours later, at the evening visit, although surrounded by cotton and bottles of hot water, no natural warmth had returned to the limb, and it was perfectly numb and destitute of feeling. The next morning the patient's condition was depressed and anxious; and, although sufficient time had now elapsed for restoration of its circulation by means of the collateral anastomosing channels, the limb was *still cold and insensible to the touch;* its color was dead white, with a purple marbling on the thigh running into a more uniform dusky tint below, with streaks of still darker color marking the track of the saphena vein and its branches. It was slightly puffy through-

* "Contributions to Surgical Practice and Pathology," Philadelphia, 1865.

out from œdematous effusion, as was proved by the pitting on pressure over the tibia. On the next day the limb was still cold as marble and very much more swollen, and, on firm pressure of the thigh, *a distinct emphysematous crackling was perceptible*, evidently from the extrication of gas among the muscles; its color was more deeply tinted with a livid, reddish purple, and a small blister containing a bloody serum had formed on the inside of the ankle. The patient's general condition was expressive of great depression, and his pulse was frequent and feeble. On the fourth day the aspect of the whole limb was utterly gangrenous; all the appearances already noted were intensified; blisters, or *phlyctænæ*, had appeared at several points, and the cuticle could be detached on moderate pressure; percussion of the thigh gave a resonant sound, from gas collected within the limb; and the odor of putrefaction was perceptible. The patient was mildly delirious, with a pulse of 120. On the sixth day he died. I subsequently made a careful examination of the limb. On cutting into it, fetid gas and a brownish-colored, turbid, watery serum escaped freely; the connective tissue seemed everywhere infected with this fluid; the muscles were soft and of a brick-red tint, and the other soft parts presented a water-soaked appearance.

Here, then, we have all the *local* symptoms of gangrene well illustrated: 1. Local depression of temperature; 2. Loss of sensibility; 3. Discoloration; 4. Formation of blisters containing blood-colored fluid, and separation of the cuticle; 5. Odor of putrefaction. In this instance little or no blood probably escaped from the limb after the sudden stoppage of the current in its main artery. The leakage of their liquid contents through the walls of its gorged vessels, the liquefaction of its tissue-cells, and the hastening of putrefaction by artificial heat, combined to explain the changes that followed. *The immediate cause of death was, probably, pure septicæmia.*

The symptoms I have just described will serve as a type of what occurs in the more rapid cases of traumatic gangrene. In many such cases, where there is no external wound, there is crushing or bruising of the inner and middle coats of an important artery, so that they retract, as in torsion, and obstruct the vessel.

Just in proportion to the gradual withdrawal of its arterial supply from a part will the resulting gangrene assume the dry character.

A calcified condition of the arterial coats from textural degeneration, together with the failure in vitality of age, constitutes the pathology of *senile gangrene.* A so-called "ossified artery" can not contract upon its contents and supplement the heart's action in propelling the blood to its destination; hence the tissues suffer, and those farthest from the center of circulation are the first to die.

This redoubtable malady makes its appearance in one of the lower limbs, very rarely attacking an upper extremity. After some months of unpleasant sensations in the part, a purplish spot is discovered upon one of the toes, generally near the root of the nail, sometimes with its cuticle raised in a blister. From this the mortification extends very slowly, the tissues usually drying into a hard, black, shrunken mass as it advances, and months may elapse before its limit is reached. This limit, when it does occur, is generally about the middle of the leg, the disease rarely reaching the knee.

Meanwhile, pain is the most prominent symptom, and this is often intolerable, rendering the use of opium a necessity. Percival Pott, the great English surgeon, ascribed curative power to this drug, but its influence is limited to palliation of pain, which is due to the lingering death of the nerves of the part. It is not invariably present, being replaced in some cases by simple numbness. Unless the patient is free from other disease, and possesses more than usual vigor and tena-

city of life, he is usually worn out before the disease limits itself. *The treatment of senile gangrene is limited to a judicious husbanding of the patient's vital resources looking to possible self-limitation of the disease, after which a cure may be completed by amputation.*

A woman of seventy was brought to St. Vincent's Hospital for the avowed purpose of getting rid of her leg, the lower part of which, with the foot, was completely black and mummified. A line of demarkation had formed some months before at mid-leg between the living and dead parts. The shrinking of the latter had created a chasm which narrowed toward its bottom, where the bones, dry and bare, could be touched by the probe; but for them, an amputation would have been completed by nature's efforts. As the patient was otherwise in good condition, I accepted the indication and removed the limb through healthy parts below the knee, and she made a good recovery. The posterior tibial artery was found completely converted into a thin tube of bone-like material.

The question of amputation always suggests itself in this disease; and, in regard to this question, I am anxious that you should be clear in your judgment, especially as it has been advocated unwisely by some as a remedy for the disease. Even although a rare exception might be possible, you will be certainly safe in following this rule: *that amputation is not proper in senile gangrene unless a line of demarkation has formed.* As the normal resources as to blood-supply of the part have already failed, as proved by the spontaneous occurrence of gangrene, unless we know exactly the point in the course of the main artery at which the failure of the blood-supply has been produced, and the reason why, we incur, in resorting to amputation, a blind risk, and a very considerable risk, of a recurrence of gangrene in the stump.

Sometimes a calcified plate, projecting with a rough

edge from the internal surface of an artery, provokes a deposit of blood-clot; in this way the vessel's caliber becomes gradually obliterated by plugging, and gangrene follows.

I have seen several instances of spontaneous gangrene of the foot in elderly patients with diabetes. The disease was always of the moist variety, and the pain was not so intolerable; but where there is sugar in the urine the prognosis is even more hopeless than in true senile gangrene.

A clot may form in the heart, or a fibrous mass, already formed, may detach itself from one of the valves and be carried on by the blood-current until it reaches an artery of a caliber too small to allow its farther passage, and here it lodges, constituting an embolus, which, by suddenly cutting off the blood-supply, threatens gangrene. This serious accident, when it involves the systemic circulation, is often preceded by a paroxysm of palpitation and oppressive breathing, and the embolism almost invariably takes place in one of the lower extremities. Its occurrence is marked by sharp pain at the site of the obstruction, sudden numbness of the limb below it, and coincident cessation of its pulses. This group of symptoms is sufficiently grave and startling to render a diagnosis of embolism and probable gangrene unmistakable.

Where the embolus is simply a fibrinous mass detached from the margin of a cardiac valve, or a small clot which has formed upon a rough projecting point of a patch of acute atheroma, the symptoms of sudden cardiac oppression may be entirely absent; but when sudden pain occurs in a limb and it grows cold and numb, these symptoms alone, occurring after middle-life, mark clearly enough the character of the case, and indicate the danger of approaching gangrene from embolism. The symptoms in the fatal illness of the late Valentine Mott were of this nature; he died, on the sixth day, "of exhaustion, attended by mild delirium."

I saw a case of gangrene of the feet not long since, in consultation, with the object of determining the propriety of amputation. The patient, a vigorous man of sixty-four, had experienced a novel sensation of difficulty of breathing one evening while sitting by his fireside. He went to bed without saying much about it, and the next morning was found to be *hemiplegic* on his right side. There had been no marked cerebral symptoms, but the heart was beating weakly and quite irregularly. A day or two afterward he complained of severe pain in the right leg and foot, and this part shortly became cold and fell into gangrene. The gangrene was moist; a line of demarkation formed slowly just below the middle of the leg. Shortly after, an eschar made its appearance on the heel of the opposite foot. At my visit I recognized evidences of heart-clot and of failing nerve-force, and, although the gangrene had limited itself, I reluctantly decided against interference, in consequence of the evidence of heart disease. The patient lived about a month, suffering but little pain, and finally died by failure of the heart.*

In cases of this kind—namely, of *gangrene from embolism*, with heart disease—amputation is rarely if ever admissible. In sixteen such cases collected by Dumaz, eleven died and three recovered; in two, amputation was done, and death followed in both.† When such cases occur in advanced life, the rule against amputation is still more imperious.

In disease of the heart in younger persons, with defective power in the organ, I have more than once seen temporary arrest of the circulation in the feet follow an attack of cardiac distress—with subsequent return of the circulation. In one case of this kind, in a woman

* This case is reported by the attending physician, Dr. Hunt, of Eatontown, N. J., in the "Transactions of the State Medical Society of New Jersey."

† Thesis on "Obliteration of Arteries of Limbs by Embolism and Thrombosis," Paris, 1872.

of forty, after several such attacks which had been recovered from, gangrene finally occurred in both feet, just after discontinuing a mixture containing digitalis, which she had thought was doing her good.

Raynaud describes * a form of spontaneous mortification attacking the fingers and toes, sometimes the nose, most frequently in chloro-anæmic women under forty, rarely fatal, and characterized, curiously, by the fact of almost complete symmetry in the parts involved. This affection is ascribed to local asphyxia from deprivation of blood-supply through extreme contraction of the smaller arteries in consequence of reflex excitation of vaso-motor nerves. The waxy, "half-dead" condition of the fingers that we see occasionally in anæmic women has the same explanation.

The mode of death in fatal cases of gangrene varies according to its seat and extent. Shock and collapse, with ineffectual effort at inflammatory repair, as in intestinal strangulation, and the addition of septicæmia, where a limb has become gangrenous, would seem to rank first in order of frequency. The "exhaustion," with "mild delirium," so often noted as preceding dissolution in gangrene, are characteristic of *septicæmia.* Death from hectic and exhaustion may follow the separation of extensive sloughs.

It is well to note that sulphureted and phosphureted hydrogen, the sources of odor in gangrene, are nauseating and depressing, but not otherwise directly fatal. Bernard injected the first-named gas into the veins of a dog—as you may remember; the animal was excessively prostrated, but recovered in an hour or two. While recovering, a sheet of white paper saturated with a salt of lead held before his nostrils was sensibly blackened by hydrosulphuret of lead. This demonstrates that gases extricated by decomposing tissues, which gain access to the blood, are eliminated by the lungs. I suppose that many of the headaches due to consti-

* "Nouv. dict. de méd. et chirurg. prat.," art. "Gangrène."

pation come from osmosis of sulphureted hydrogen extricated by fecal matter in the large bowel; they are usually relieved by breathing fresh air. Where these gases are introduced into the blood, not by absorption from within, but through the lungs from without—in moderate amount, perhaps, but for a longer period—as in the case of the patient who breathes foul air in the ward of a hospital, or who has a gangrenous limb that taints the air he is forced to inhale, there is more danger to life; for, thus situated, he is cut off from safety by means of conservative ventilation of the blood through the lungs. Even here the real danger is not direct, but indirect; it comes from continuous depression of the powers of life by the diluted noxious agent, through the effect of which he is rendered less able to resist other poisonous influences rather than by the power to kill possessed by the offensive gases themselves. Thus the general impression that bad smells alone do not kill has some foundation; but they do produce temporary depression of the nerve-force, as is proved by the nausea they provoke.

In regard to the *treatment* of gangrene, it is obvious, from what I have said, that its prevention is best attained, in *the first place*, by such measures as will secure an adequate supply of blood, or an improved quality of blood, to the threatened part; and, in *the second place*, by antagonizing any poisonous influence that may unfavorably affect the vitality of the tissues.

The free incisions of the skin, to relieve the obstructive tension of its nutrient vessels, and the removal of injurious constriction or compression—as by loosening a tight bandage or by placing a paraplegic patient upon a water-bed so as to distribute more equally the pressure upon his body—are examples of remedies by which the first indication may be met; while an improved quality of food or an exclusive meat diet, to diminish the amount of sugar in the blood of a diabetic patient, illustrates the means of meeting the second indication.

It is of the first importance, therefore, to secure for a part threatened with death the position and surrounding circumstances which will favor its circulation, and to support the patient with the best form of tonic and substantial nourishment. Alcohol, in some form, is of service as food to aid digestion and to protect the nervous centers from shock; it also serves to antagonize the depressing influence of sulphureted hydrogen; but it must be given moderately, for there is danger of overstimulating the heart.

Are there any drugs which have power to arrest the progress of gangrene after it has fairly begun? Both opium and "bark," in former times, enjoyed this reputation; but, while they have great value in aiding the sufferer to bear pain and in supporting the powers of life, *neither possesses any specific virtue in arresting mortification.* Digitalis certainly is serviceable in steadying the action of the heart when it contains a clot, and in stimulating its muscular force when defect in this respect is an element in the causation of gangrene. Alkalies have the credit of temporarily increasing the oxygen of the blood and of rendering it more fluid, thus preventing thrombosis in case of stasis. Carbonate of ammonia with bicarbonate of potass or soda would be a desirable combination. I do not see why inhalation of oxygen, when feasible, should be neglected.

Deodorizers are usually required; of these, the best are the permanganate of potass and the chlorides of soda, zinc, or lime. Carbolic acid, which is generally used with liberality under the general conviction that it kills poisonous germs and prevents putrefactive fermentation, can not in any other sense be properly called a deodorizer. When gangrene of a limb is threatened, or has actually taken place, amputation, as a measure possibly competent to save life, can not be overlooked. I have already spoken favorably of the primary amputation of an utterly crushed limb as a preventive of fatal septicæma. The general rule has also been laid

down that *in actual gangrene amputation is not proper until it has ceased to advance and a line of demarkation has formed.* To this rule there is this exception: When, after ligature, or injury causing obstruction of the main artery of a limb, mortification takes place, commencing in the toes, then it is justifiable to amputate at once, and the point selected for the operation should be as near as possible to the seat of the obstruction in the artery, and the operation should be done at the earliest possible moment after the first manifestation of gangrene. Here the cause and nature and exact locality of the arterial obstruction are known. In such cases, especially in an upper extremity, a line of demarkation often forms. In the lower extremity, self-limitation of the advancing gangrene is rather the exception, and a fatal result the rule.

But when, under the circumstances I have stated, a large portion of a limb falls into gangrene, a line of demarkation must be awaited; otherwise the stump will be most probably invaded.

In the separation of partial sloughs, the aid of the surgeon's knife and scissors may be required. In detaching them, it is to be remembered that the blood-vessels are very tenacious of life, and, to avoid bleeding, must be respected.

Yeast and charcoal are favorite ingredients in poultices for promoting the separation of sloughs; they may be replaced by lighter dressings saturated with deodorizers or carbolic-acid lotion.

CHAPTER XXII.

Inflammation.

BEFORE going on to the subject of tumors it may be as well to finish the little that remains for me to say concerning inflammation. Contrary to the usual plan, I have left it to this late period of the course, because, in our efforts to comprehend inflammation, we are aided by the illustrations of its several features furnished by a previous familiarity with surgical diseases and injuries, and the methods by which nature strives to repair them.

Heretofore, under the inspiration of John Hunter, all the phenomena of this process of repair, even those attending the primary union of the simplest wound, have been treated of under the head of inflammation, and, in fact, are still so treated by systematic writers on surgery. The Hunterian term "adhesive inflammation," and the expression "healthy inflammation," are usually employed to designate the phases of what I have thus far spoken of as the *normal process of repair.*

The histological appearances which the microscope has shown us since his day has justified the prescience of Hunter by showing the identity in the earlier stages of inflammation — both in the anatomical elements affected, and in the changes which take place in them after the injury—between inflammation and the simple reparative process. It has also taught us the real difference between this: the *constructive* phase of the inflammatory process and the series of changes proper-

ly distinguished as *destructive* which result as consequences from its failure.

These latter, which comprise suppuration, ulceration, and gangrene, are the natural consequences of the imperfect resources of our organism in the way of repairing injuries.

The term inflammation is obviously not applicable to textural changes which are due to imperfect nutrition, nor yet to the various changes to which the microscopic cell is liable while playing its part in the organism—changes described by Rindfleisch and other modern pathologists under the already well-known terms of "fatty infiltration" and "degeneration," "cloudy swelling," "mucoid softening," "calcification," "amyloid degeneration," etc. These cell transformations which look toward decay and death, not only of themselves individually as cells, but of our organs and bodies of which they constitute the living elements, are all to be subtracted from the results formerly ascribed to inflammation. Thus we are in the way of learning more of the true nature of inflammation by finding out *what it is not* than *what it is.*

Let us rapidly sum up the anatomical and physiological facts which constitute inflammation as far as they may be of service to us clinically.

The first of the series of phenomena that follow a hurt or local injury to a part is *a sudden effort at contraction of its blood-vessels.* This is always of short duration, evanescent, sometimes even not noticeable; and it is invaribly succeeded, after a short interval, by the opposite condition of *dilatation;* this is longer in its duration and more important in its results. Thus, to the eye, there is momentary pallor, surely and quickly followed by increased redness, as a consequence of every injury to the living tissues, whether mechanical, chemical, or poisonous, which does not kill them outright; and with these phenomena a remarkable increase in velocity of the circulating current. A scratch of the finger-nail

upon the fore-arm, or a drop of nitric acid upon the skin, will illustrate this; they cause first pallor, and then increased redness, and it is clearly demonstrable by pricking with a needle the web of a frog's foot when its capillary circulation is displayed under the microscope.

Sir James Paget's experiment upon the wing of a bat, a warm-blooded animal more nearly allied to man than the frog, is especially satisfactory. "If, as one is watching the movement of blood in a companion artery and vein," he says, "the point of a fine needle be drawn across them three or four times without apparently injuring them or the membrane over them, they will both presently gradually contract and close. Then, after holding themselves in the contracted state for a few minutes, they will begin again to open, and, gradually dilating, will acquire a larger size than they had before the stimulus was applied." ("Lectures," etc., *ut supra*, p. 225.)

These experiments, although apparently trivial, are, in fact, of much significance, for they lead us for the first time to consider the nerves of a part which has been subjected to injury, and they show us how these nerves act; for the cause of disturbance of circulation in the blood-vessels is first felt by the nerves, and its impression is transmitted by them to the blood-vessels. The cut or blow causing the sharp pain conveyed to our consciousness in the brain through a sensory nerve also impresses a certain influence simultaneously, through nerves provided expressly for this purpose, upon the blood-vessels of the part hurt. Filaments of these nerves, called *vaso-motor* because they regulate the amount of blood sent to the tissues through their blood-vessels for nutritive purposes, are found in the compound cerebro-spinal nerves along with sensory and motor fibers. They also accompany the greater sympathetic trunks, for, when Bernard divided the main trunk of this system of nerves in the neck of a rabbit, the animal's ear of the same side became intensely con-

gested, *because the nerve regulating the blood-supply had been cut off;* and, for the same reason, when Samuels cut out the cœliac plexus in the abdomen, the mucous membrane of the stomach was found gorged with blood.

Through our knowledge of these vaso-motor nerves we account for the pallor caused by sudden fright, and the glow that follows; for the redness of the conjunctiva that comes from rubbing the eye; in short, for the redness that follows friction of any part of the body. Here the action of the nerves is reflex, and it is also in this reflex way that their influence is brought to bear upon the blood-vessels of a part subjected to violence, causing the *afflux* of blood which invariably sets in toward the point of injury, and which constitutes the second of the series of changes, etc.

The significance of this rapid afflux of blood to a part which has sustained injury is, no doubt, conservative. It has the same meaning as the rush of blood to the capillaries of an empty stomach when food enters it; or to the mammary gland of a nursing woman when her child draws at the nipple. The afflux of blood toward an injured part carries to it an increase of nutritive power, with the greater number of blood corpuscles, and greater volume of liquor sanguinis, as shown by enlargement of vessels and increased rapidity of current—*these together constituting a supply of materials for repair.* We shall find evidence of this when we come to inquire what becomes of the blood thus brought to an injured part. Meanwhile, the part is *red;* it is what is called "*congested*"; it is in a state of *hyperæmia.* By the application of a mustard-plaster, which acts as a chemical irritant, or as a poison, we can produce this phenomenon upon the skin at will. As we know by observation, when the sinapism is removed the redness after a little disappears—i. e., the capillaries of the part gradually shrink again to their original size; the effect of the injurious impression has worn out, and the part returns to a state of health.

This is an example of "delitescence," or *resolution, of the state of abnormal congestion—which is usually regarded as the first stage of inflammation.*

But when the source of irritation—the "injury" to a part—is not temporary and evanescent, when it is persistent, intensified, or repeated, then its capillary vessels remain congested, and other phenomena gradually make their appearance. These are *increasing distention of the vessels; liquid and solid exudation through their walls;* and, finally, *entire stagnation of the capillary current.*

The picture already seen of irregularly distended capillaries with their contents carried along by a quickened current is modified by a *curious tendency of the white-blood corpuscles to lag behind and arrange themselves in contact with the walls of the vessel, to which some of them manifest a tendency to adhere.* This behavior of the white-blood globules is the first step toward *migration;* and this migration they accomplish by working their way through the walls of the capillaries in the manner I have already described to you. Meanwhile, the central current, composed almost entirely of red-blood globules, becomes more and more crowded, and it soon begins perceptibly to run somewhat more slowly.

The proportion of the liquor sanguinis to the globules in the capillary current has become less than usual, a circumstance which also tends to retard its velocity. This diminution in the proportion of liquor sanguinis is accounted for by the *liquid exudation* through the walls of the vessels, which has been going on in an increased amount. I say in an increased amount, because this sweating or exudation through the capillary walls is a feature in the mechanism of normal nutritive process by which the tissues are nourished from the blood. But now the exuded material is increased in quantity, and probably altered in its nature, as we shall shortly see.

Finally, after the lapse of some hours, the caliber of the vessel having become gorged to its extreme capacity with blood corpuscles, and the liquor sanguinis having, apparently, all exuded through its walls, the current becomes slower and slower, and presently, after a few hesitating, oscillatory movements, it ceases entirely. Thus the condition of *stagnation*, or *stasis*, is reached, liquid exudation having been pretty much accomplished, and cell migration still going on. Exudation and stasis are the third and fourth in the series of changes.

Meanwhile, the circulation in the vessels immediately around those in which stasis has taken place is still progressing at an accelerated rate of speed. *The sharpness of stroke noticeable in the smaller arteries leading to an area of capillaries blocked by the stasis of acute inflammation is thus explained.* In a bad felon in a finger it can often be detected in the radial artery of the affected side.

I may remark here that the explanation of the outward phenomena of pain, heat, redness, and swelling is now fully manifest; as the greater afflux of red blood accounts for the increased *redness* of a part in which the changes just described are going on, so does the exaggerated exudation from its blood-vessels explain the *swelling;* while the greater quantity of blood in the part, and the increased activity of vital and chemical action, readily afford reasons for a greater degree of *heat*, and the tension of numberless sensitive nervous filaments accounts for the *pain.*

It would seem that the blood accumulated in the capillaries after stasis is *not apt to coagulate*, that it may possibly resume its flow, and that the inflammatory effort, even at this stage, may end by resolution.

I have already detailed in part the changes in the neighboring connective tissue which follow exudation, stasis, and cell migration, as observed under the microscope in tissues experimentally injured; but, in con-

nection with the several different forms liable to be assumed by *inflammatory exudation*, it is well to recall what we have learned concerning it.

In the first place, as we have seen, there is a soakage of the substance of the connective tissue by the blood plasma which has abundantly exuded into its meshes, and which bathes and saturates the old and apparently withered connective-tissue corpuscles lodged among its fibers. These old corpuscles begin to lose their shriveled aspect under the stimulus of this bath of blood plasma, and swell into increased size by the accumulation of protoplasm newly developed within them; their nuclei begin to enlarge, and the protoplasm becomes granular in aspect. In twenty-four hours the nuclei have separated—each into several distinct divisions, each of which has invested itself with a share of the protoplasm, and presents itself as a new young cell—such as can be seen in the embryo when development is about to take place. To this newly formed progeny are added the emigrant white-blood cells—the solid material of exudation—which, to use the term first applied to them by the Germans, "wandering" in the meshes of the adjacent tissue, find themselves in the company of their kindred organisms, the young embryonic cells, from which, as we have shown, they differ in no respect—being, like them, "leucocytes"—except, possibly, that they may possess increased germinal power from having been more recently bathed in the blood-current. Thus the process of *cell germination or proliferation*—the fifth in the series of phenomena which constitute inflammation—is still further stimulated.

Meanwhile, the *fibers of the connective tissue*, between which these young cells can be seen squeezing themselves in rows, begin themselves to lose the distinctness of their outline, to fade out, gradually, as though they were dissolving; and, in fact, they are presently lost to sight—being *replaced by a jelly-like*

mass, in which the young cells alone are seen. These latter, increasing constantly in number as the germinating process goes on, soon leave very little intercellular space visible except that which intervenes between the points at which they touch each other. In this mass of cells, all about the same size and aspect, we soon detect moving currents of blood corpuscles, and then the outline of the *walls of capillary vessels can* be made out, and thus the result begins to recall the appearance of what you are already familiar with under the names of embryonic, or young connective tissue, which I have described to you under the name of granulation tissue.

Notice, meanwhile, that the *cell germination* which has brought about this result has been accomplished at the expense of pre-existing tissue, and that it has been attended necessarily by arrest of function in the parts in which these changes have been going on. The scarcely perceptible old connective-tissue corpuscles, with their dormant nuclei, had originally brought into existence the comparatively dry bundles of cobweb-like fibers (among which, after having assumed a determinate form, they were quietly reposing), and which, as a part of the original "vascular tissue" of the embryo, had served and was still serving to surround and support the blood-vessels and connect them to the parts they were destined to nourish, which, as you know, is the normal function of connective tissue; now, these old connective-tissue corpuscles are stirred up again to life and action, by the irritation of injury, to make new connective tissue for the purpose ostensibly of repair. But their former uses are temporarily suspended, perhaps permanently abolished.

Possibly the neoplasm which results from this series of changes in the progress of its development into connective tissue might, under other and possible circumstances, fatally interfere with the delicate structure of a secreting gland or some vital organ, or prove the

starting-point of a tumor. We have a striking illustration of this possibility in the pathology of *cirrhosis* of the liver, with which you are probably familiar. Alcohol, circulating habitually in the hepatic vessels, acts as a chemical irritant and produces inflammatory exudation in the surrounding connective tissue or parenchyma of the organ, and the consequent cell proliferation results in its solidification and subsequent contraction. By this the glandular elements of the liver, as well as its larger vessels, are fatally compressed, the whole organ contracted, and its surface becomes covered with knobby eminences, which have given it the name of the hobnail, or drunkard's liver. I would have you infer from this that inflammation, when it advances beyond its earlier stages of increased nutritive action, is necessarily characterized by interference with function in the inflamed tissue or organ, possibly of over-growth, and that the uses of the inflamed part are in danger of permanent impairment, possibly of destruction.

In the pathology of the present day, simple cell proliferation under the influence of slight irritation constitutes *hyperplasia*—a term in general use, originally coined by Virchow, and meaning, literally, *an increase in the number of the individual structural elements of a part.* If the irritation be diminished or withdrawn, the embryonal cells "return to their former condition and form tissue similar to that from which they sprung." But if the inflammation persists and becomes more intense, the old tissue is destroyed and disappears in the manner I have detailed, and the embryonal cells organize into a tissue which has deviated from the primitive type, or they become incapable of constituting a definite tissue, *and form pus.* (Cornil and Ranvier.)

The phenomena of inflammation thus far noted include mainly anatomical changes which are entirely demonstrable. Is there any inflammatory change in the blood concerning which organic chemistry can give us information? Only this: There is good reason to believe

that there is a very moderate increase in the relative quantity of fibrin; certainly a tendency to the formation of an increased amount of this substance by chemico-vital changes coincident with the inflammatory excitement. (A. Schmidt; Cornil and Ranvier.) But this would seem to occur only when there is fever, with symptoms of what we call *acute* inflammation—i. e., where the cardinal symptoms of pain, heat, redness, and swelling are present in a positive degree. The largest amount of fibrin has been found in acute inflammatory rheumatism and pneumonia, in acute tonsillitis, erysipelas, and acutely suppurating glands. (Follin, from Andral and Gavarret.)

The so-called *inflammatory crust seen on blood-clot* was formerly regarded as very significant and as justifying bleeding from the arm as a remedy. But this appearance is often seen in the blood of pregnant women in perfect health, and Andral found it even in the thin blood of chlorotic girls. At the present time little importance is attached to it.

Of the *nature of the exudations* which escape through the walls of the capillaries under the influence of inflammatory congestion it seems to be the best opinion that they are mainly serous, containing a *variable quantity of "fibrinogenous matter,"* which coagulates only after escaping from the vessels. Plastic lymph deposited on the surface of a recent wound is one of the results of this coagulation. *According to the latest authorities* (Cornil and Ranvier), *it takes place suddenly, as it were, by precipitation from the serous discharge in successive layers, the exudation in contact with the tissues alone coagulating.* In this form, upon a wounded surface, we have seen that it serves as a hot-bed, or blastema, in which cell germination takes place. On serous membranes this same exudation takes the shape of what are called "false membranes," which may become organized into connective tissue.

There is a more purely serous form of inflammatory exudation, which is highly albuminous, but does not coagulate; of this, the fluid that collects in the tunica vaginalis during an epididymitis, or in connection with a syphilitic orchitis, are examples. This same fluid is found in the cavity of the pleura, and in that of the peritonæum, in certain grades of inflammation, and also in the meshes of the connective tissue; but it differs from the serum of *ordinary anasarca, which contains absolutely no fibrinogenous matter whatever.*

According to Cornil and Ranvier, following Virchow, *mucous* exudations take place from mucous, and also from synovial, membranes, and, under acetic acid, deposit filaments of the substance known as *mucin.* These filaments of mucin "form thick layers upon the surfaces of articular cartilages, notably in white swellings." What the Germans call *croupous exudation* consists of cell elements with filaments of mucin and fibrin.

The true *diphtheritic exudation*, according to Wagner, consists of epithelial cells which have undergone a peculiar enlargement and a fibrinous degeneration under the influence of the specific diphtheritic poison.

In studying the subject of *inflammatory exudations*, the imperfection of our knowledge is manifested by the diversity of opinion among those who have devoted most attention to it.

It remains for us to notice the *new formation of capillary vessels*, in inflammation, which succeeds the massing of embryonic cells, and which is the last of the series of anatomical phenomena which are regarded as characteristic of inflammation. This curious effort at development involves changes in the flattened cells of protoplasm forming the capillary walls. These cells swell and soften, and send out processes which connect themselves with adjacent vessels. They also give issue, by solution of continuity, or rupture, to slender streams of red globules which channel their way through the

mass of newly formed embryonic cells, and these new cells flatten themselves out to form walls for the new currents.

This series of changes, then, according to the teachings of modern pathology, constitutes inflammation.

To sum up, they comprise *afflux* of blood to the affected part, with increased rapidity of current; an increase of *exudation*, more or less altered in its nature from the blood plasma; stagnation, or stasis of blood in the distended vessels; *cell germination and proliferation*, replacing original tissue by a mass of embryonic cells; and, finally, the *formation of new capillary vessels* in this mass of cells, and its *organization as young connective tissue*, confirming Stricker's definition.

Notice that the *seat of all these phenomena is in the capillary vessels, and in the connective tissue immediately surrounding them; and that they greatly resemble the ordinary features of the process of normal nutrition.*

It is not easy to believe *that there is any other than a constructive or reparative purpose in this series of changes to which we are compelled by scientific precision to confine the definition of inflammation.* The simple fact that they invariably follow injury, and, as a rule, result in the repair of injury, is certainly *suggestive of their conservative character.*

Why, then, is inflammation habitually spoken of as the fertile source of so many evils; as the ideal adversary to be continually contended with by the surgeon, as his main business, in striving to avoid bad results in treating wounds?

As I have already intimated, this is, in a certain sense, *a pathological fiction; the term inflammation has been used to a great degree as a convenient expression to mask our want of precise knowledge of the real causes of the ill-behavior of wounds.*

As we gain more familiarity with these causes we shall probably hear less of the destructive consequences

of inflammation. At least, in view of our absolute ignorance of any essential nature or quality of inflammation beyond what may be inferred from the statement which I have laid before you, and this comprises about all the exact knowledge we possess, I feel justified in expressing this opinion.

The so-called "destructive" tendencies of inflammation, as far as I can see, have their fundamental causes in, first, the limited power inherent in our complex organisms to repair injuries; second, in the character of a given injury, as rendering its repair difficult of attainment; third, in the presence and effects of septic, or otherwise mischievous, poisons, or other detrimental influences; fourth, in the noxious effects of crowding and unhealthy modes of life, upon our organisms, which render them unable to resist these detrimental influences; and, finally, *in the want of sufficiently accurate knowledge of nature's methods to guide us in managing wounds in accordance with them.*

I may illustrate my meaning by passing in review some of the phases of a grave surgical case—a compound fracture of the leg, for example. This is a surgical accident in which amputation is often called for to save life, not only as a primary operation, through conviction, by the teachings of experience, that the powers of the organism are not equal to its repair, but also, later, to avert the consequences of exhaustion from suppuration and abscess (usually ascribed to inflammation), and threatened death by hectic.

If at the outset of such a case the surgeon succeed in closing the wound and converting the compound fracture into a simple one, his art proves all-sufficient, and the cure follows, as in all subcutaneous lesions, without any delay beyond what is required for the uncomplicated process of repair. If he fail in closing the wound, then trouble and delay in the cure begin. The broken bones, say of the leg, and the open wound communicating with them, are situated almost invari-

ably at the anterior surface of the limb, which, from necessity, is placed for treatment upon its posterior surface. The fluids which accumulate at the point of fracture, and in the unclosed wound, have no means of escape except by overflow, and they necessarily tend to gravitate to the bottom of the wound among the muscles at the deeper parts of the limb, where they provoke inflammation, abscess, and burrowing. Here is the first inherent difficulty arising from the character of the injury; and, in consequence of this, treatment may become powerless unless very skillfully directed. The indication is to keep the fragments of the broken bones in apposition and at rest, in order to secure their union; but the embryonic tissue, that forms for the purpose of closing the wound in the soft parts, will undergo heteroplastic change and run off in the shape of pus while awaiting the slower process of healing in the bone; and there is danger of *necrosis* and *osteo-myelitis* in consequence of the fragments being constantly bathed in pus which has no outlet except by overflow from the wound. Moreover, the patient is exposed, especially in a hospital, to the other dangers which attend open wounds.

The most promising treatment in this contingency would be to suspend the leg in a firm dressing from a frame or cradle, to make an opening through the limb posteriorly from the wound, and to insert one or more caoutchouc tubes through it so that the pus may drain away through a depending outlet as fast as it forms, thus effecting what is called "*through drainage.*" This measure, if promptly and successfully carried out, will certainly, under favorable circumstances, stop the burrowing pain and attendant fever; in other words, it will cut short the destructive symptoms of inflammation. These symptoms are obviously caused by the unpropitious attitude of the injured parts, and the influences which, by interfering with the simple process of repair, *under the conditions by which repair is*

effected in our organisms, rendered suppuration a necessity.

Mr. Lister has proved that, by the early and faithful employment of his antiseptic appliances, repair may be attained, even under the untoward conditions of injury presented by a bad compound fracture of the leg, without suppuration.

I can not take time to pursue the illustrative case further, but it seems to me that its points justify us in asking ourselves whether it is not more rational to ascribe such symptoms as I have detailed—i. e., suppuration, abscess, and delay in healing—to natural and often preventable causes entirely sufficient to account for them, and which the mind can grasp, rather than to an unintelligible something—called, for convenience, inflammation—the real nature of which, if it have any beyond what we have set forth, has so far utterly eluded research?

Inflammation, then, as far as we certainly know, consists in a series of changes which take place, mainly if not entirely, in the capillary vessels of a part and the connective tissue surrounding them, and which, if not interrupted, result in cell proliferation and the formation of embryonic, and ultimately of connective, tissue.

We have studied the phenomena of inflammation, for convenience, in the connective tissue, because this tissue exists pretty much everywhere in the body, and is always in immediate relation to the capillary vessels; but in all the other tissues the main phenomena of the process, with the exception of certain incidental peculiarities, are the same. Everywhere its characteristic result, if not prevented, is cell proliferation and formation of embryonic tissue. When this result is somewhat interfered with, some of the new cells fail of complete development, and are cast out as pus, *suppuration*. Sometimes when the inflammatory process is very acute the stasis is extensive, with occasional rupture of ves-

sels and escape of red- as well as white-blood globules, and local death takes place in a limited area, through cutting off of the usual blood-supply. This is the "termination" of inflammation in *gangrene.*

When pus collects in the tissues, as in abscess, its pressure is liable to produce the same result—namely, death of tissue—but by slower wasting or molecular death of the tissues whose blood-supply has been interfered with; this constitutes the "termination" in ulceration. *Chronic inflammation* has been already described as characterized by habitually enlarged vessels and swelling, or induration from partially developed embryonic tissue.

Here, then, with the exception of *resolution*, which has been already noticed, we have all the incidental consequences of inflammation which have been usually described as its *terminations*—namely, *suppuration, ulceration, gangrene, and induration.* These terms at present are mainly used in the sense ascribed to them, *like the term inflammation*, for the sake of convenience; for, with the exception of resolution, they are obviously not real terminations of the process. As we now regard it, they are incidental consequences of the inflammatory condition, but not strictly and literally its terminations.

It follows, also, from our present view of the subject, that the old distinction between *traumatic* and *idiopathic* inflammation is no longer tenable. An *idiopathic* affection is necessarily spontaneous, not preceded by anything that acts as a cause; but inflammation, as far as we can learn, is nothing more than a series of changes that follow injury, and *can not, therefore, originate of itself.* Every inflammation must have a cause potent enough to provoke the "series of changes," and this cause is technically called an "injury"—whether it be inflicted from without, as a wound, or from within, as from acrid ingesta irritating the surface of the intestine; *or it may arise from*

alteration or death of a portion of tissue acting as a foreign body, or from perverted nervous influence, or from a poison in the blood. In this sense, therefore, *every inflammation* is traumatic, and the term idiopathic has no longer any significance as applied to it.

In connection with the *causes* of inflammation, we are hardly sufficiently awake to the fact that the simple contact of certain poisons with the tissues may act as an efficient provocation. The "specific induration," as it is called, which characterizes the primary lesion of syphilis and gives it the name of hard chancre, is *due to cell proliferation.* In those unfortunate cases in which an obstetrician is inoculated with the virus of syphilis through a hang-nail, or a scratch of the finger, I have been struck with the general thickening that follows from cell proliferation, often involving one or two phalanges. A primary syphilitic sore on the lip of a young woman is remarkable for its abundant induration.

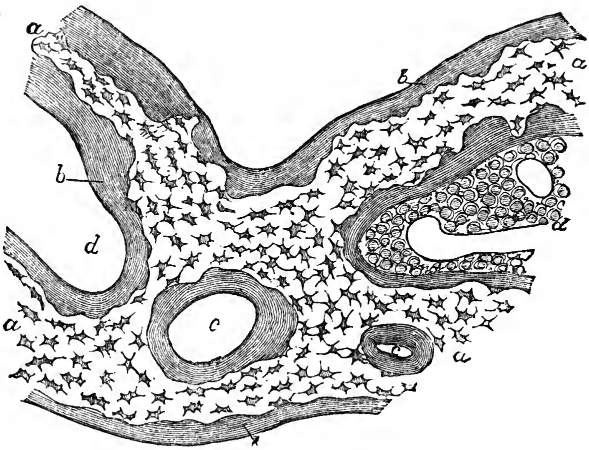
It would be a profitable study to follow out the peculiar features manifested in other tissues besides the connective by the series of changes which constitute inflammation. I have already called your attention to the behavior of some of the non-vascular tissues in connection with healing. In *cartilage*, for example, its peculiar substance, by the proliferation of its own cells, was converted into embryonic, and then into connective, tissue, as you saw in the representation of the result of the experiment on the rabbit's rib. The same changes take place in the cartilages of incrustation; so that after a hip-joint disease, if the inflammatory changes have not involved the structures of the joint too extensively and given rise to pus formation, its articular surfaces may be left bound together by newly formed connective tissue, constituting what is called "fibrous ankylosis."

In inflammation of *bone*, the walls of the Haversian canals always, of necessity, undergo absorption, so

that there may be room for the increased afflux which must precede proliferation and repair. Hence the slowness of the process in this tissue. Under a continuance of irritation, the condition of *caries* or *osteitis* may follow; or, absorption persisting, the condition called *rarefying osteitis* may ensue, in which there is little tendency to repair by formation of new bone. In bone there are cells of no less than four distinct varieties (not counting those which lie buried in the lacunæ), all of which take on rapid germination under the stimulus of injury. The true marrow-cells (*médullo-celles* of Robin) already closely resemble embryonic leucocytes, and the large, peculiar cells with many nuclei (the *myéloplaxes* of Robin), which lie free and isolated in the medullary cavities, will be both encountered hereafter as forming the substance of a not uncommon variety of tumor—the *myeloid sarcoma.* Besides these, there are large, ordinary fat-cells; and, finally, those of connective tissue. It is unnecessary to describe the behavior of the first two varieties, which are already but little removed from the embryonic stage; and with the last two you are already familiar. It is sufficient to say now that, if an incision be made over the end of one of the long bones of a rabbit, and a bone-drill inserted into its spongy substance, the animal may be killed on the third day with the certainty of finding cell proliferation already fully established around the seat of the injury. If the bone be then soaked in an acid solution so that it may be cut, and a thin section be placed under a magnifying power of a hundred diameters, masses of young embryonic cells will be recognized in the immediate neighborhood of the track of the drill (Fig. 14). Observe that the thin plate of bone forming the wall of one of the cancelli is being apparently eaten away by the growing masses of neoplasm which are developed, at its expense, out of its substance. This neoplasm, if the case progress favorably toward repair, will be ultimately converted into bone by the addition

of earth salts; if not, it may stop short at the stage of connective tissue, as in ununited fracture, or fail of its object entirely, and break down into pus.

FIG. 14.



Inflamed bone.

When the *adipose tissue* is the seat of irritation from injury, the nuclei of the fat-cells begin to proliferate, and, the oily contents of the cell being absorbed or discharged, its cavity is soon filled by their progeny—*not of young fat-cells, but of young connective-tissue cells*—ready to take on development into cicatricial tissue. This is important, as it shows that fatty surfaces will not fail, under favorable circumstances, to unite. Thus, I have had primary union, after a Syme's amputation at the ankle, between the fatty cushion of the heel flap and the cartilaginous surfaces of the tibia and fibula. And, after the removal of large fatty tumors, if judicious drainage is employed to convey away the superabundance of oil that is liable to escape from the injured fat-cells, and gentle and equable pressure is applied to keep the surfaces in apposition, good union, according to my experience, may be expected.

In injury of *muscular tissue*, the burden of action, reparative or inflammatory, is borne by the connective tissue by which the fleshy particles are enveloped, and its blood-vessels. The sarcous elements liquefy and are absorbed. This is shown by the result; for a wound of muscle is always united by connective, and never by muscular, tissue.

A man received a knife wound of the belly involving the thickness of the abdominal muscles, but not injuring any of the viscera. The wound was closed by twisted sutures deeply applied, and recovery followed. A month later the man applied for a truss to prevent the intestines from bulging at the seat of the wound, where the abdominal wall already looked thin and over-stretched, and was obviously unable to resist the pressure from within, for, when he coughed, the projection was very considerable. The muscular fibers had evidently retracted in every direction, leaving a large gap which was filled only by connective tissue, and this had proved incompetent to replace the muscular tissue in function.

In *nerves* the proliferative changes take place entirely in the neurilemma; as far as we know, it has not been accurately determined how the nerve substance proper behaves. The fact has, nevertheless, been amply proved that the ends of a divided nerve will unite with restoration of function. Richet, one of the surgeons of the Hôtel Dieu, at Paris, in 1872, reunited the ends of a divided median nerve at the wrist by a silver suture, and restoration of function of the nerve followed. The experiment constantly succeeds in the dog. In 1873, Legros demonstrated under the microscope union of the nerves of the spleen in a dog, which nerves he had previously divided. My learned colleague, the professor of physiology in this school, who so rarely fails in his experiments, had on one occasion divided the pneumogastric nerve in a dog in order to show, some time later, before the class, the fatal effect of dividing the remain-

ing pneumogastric. To his surprise, the animal did not die, as he should have done in obedience to physiological law. On examination, it was found that the *nerve first divided had grown together again.* And this union of the pneumogastric nerve, after its experimental division in the dog, has been observed by other physiologists. *Epithelial cells* respond readily to the irritation of injury much more promptly than those of the epidermis. In the case of *mucous membrane* artificially irritated, the outer cells are first thrown off, and the younger cells beneath exhibit the germinal impulse by multiplying their nuclei and swelling up with protoplasm until each becomes a nest of young embryonic cells, and then bursts and disgorges them. *Deprived thus of blood-supply, if discharged on the free surface of a mucous membrane their further power of germination and development is arrested, and they are washed away in the liquid exudation, as pus.*

The epithelium of *serous membranes* behaves in a precisely similar manner as far as the germinal activity of its cells is concerned; but there seems to exist, in irritation of serous membranes, a tendency to a more fibrinous exudation of plastic lymph, which glues them fast on its surface and leads to the formation of *false membranes*, which possess, in consequence, a certain power of self-organization into connective tissue. Under the influence of a stronger inflammation-producing cause, or under circumstances unfavorable for repair—as in blood-poisoning—the epithelium of a serous membrane, however, may be thrown off as pus, as in a mucous membrane; it is associated with serum which varies in amount and in its degree of coagulating power according to the vital force of the subject. In a recorded experiment (Cornil and Ranvier), twenty-four hours after an artificial peritonitis had been excited by the injection of a small quantity of nitrate-of-silver solution into the cavity of the peritonæum of a rat a turbid fluid containing cellular elements was found on

laying it open. Of these cells, all derived from the epithelium of the serous membrane, some resembled young pus corpuscles, some were larger, containing one or more nuclei—old pus corpuscles—and others were in an intermediate stage. In another case, examined at the end of the fifth day, many of the detached cells were found already in a condition of fatty degeneration. Thus, in man, peritonitis from surgical causes may be *local* or *general;* it may be attended with *plastic exudation* or by *effusion;* and the effusion may be *serous, sero-purulent*, or *purulent.* The same holds in regard to the other serous membranes. Before leaving the subject of inflammation, I have a final word to say: Endeavor not to regard inflammation as the cruel and dangerous *disease* which it is almost universally considered to be, popularly and even professionally. Our usual expressions concerning it and the terms employed in text-books are mostly based on this idea, and tend to perpetuate it. We have seen that our latest and most exact knowledge of its phenomena are not in accordance with this view of the nature of inflammation; that it is not, strictly speaking, a disease, but rather a natural process—a series of changes undertaken with the general purpose, so to speak, of repairing injury or getting rid of foreign and hurtful matter in the economy. When this purpose is not attainable, the destructive results that may follow are not referable to the so-called inflammation, but they are the outcome of other influences *which it is the province of our knowledge to avert.*

As inflammation does not appear to be a disease, I have given you no treatment for it. But I have told you that quietness and rest, secured, if necessary, by opium, position, cleanliness, ample air-supply, careful attention to the natural functions of the body, the generous application of leeches in case of excessive afflux, free incisions, drainage of wounds, antiseptics, antidotes—like mercury—to poisons—all promote the favorable

progress of the series of changes which constitute inflammation and prevent extravagant efforts leading to disastrous results.

Do not rely upon general blood-letting, or purging, or blistering, or mercury, except in syphilis; or digitalis, or aconite, or veratrum viride, or any other of the so-called "antiphlogistic remedies"—as if you were treating a disease. These agents all have more or less value in certain phases of morbid action, which you will learn at clinical lectures or by bed-side observation. Get all the good out of them you can, but do not use them in a perfunctory way, after the manner of the ancients, or, indeed, of many modern practitioners, simply because they have been classified as "*antiphlogistics*."

CHAPTER XXIII.

Fractures.

After having considered thus far the nature and modes of repair of lesions of the soft parts of the body, we shall next take up the subject of fractures.

Injuries of this class are exceedingly common, and the surgeon especially is held responsible for their management. They always take place suddenly, as the result of accident; and it is therefore necessary that he should be prepared beforehand to take charge of them intelligently. They lead, not infrequently, from the very nature of the lesion, to disability and permanent lameness, even after the most judicious treatment; but you will soon learn, as humanity is constituted, that your patients will place by far the largest share of the blame upon your shoulders in case of shortening, disfigurement, or loss of use of a broken limb that has been committed to your charge. An unsightly result after a fracture is a permanent subject of remark; and if there be any lack of intelligence or good-will on the part of the patient, it will not fail to operate to the disadvantage of his surgeon. You can not afford, therefore, to neglect this specially surgical subject; and, in addition to the details of treatment applicable to individual fractures which you will learn from the demonstrative lectures and from your attendance at the hospital and the clinics, I shall lay before you certain general considerations necessary to complete your knowledge of the subject.

A fracture, in the language of surgery, is a breach

in the continuity of a bone or of a cartilage, effected suddenly by external violence or as a result of muscular contraction.

Fracture may be produced by either external violence or by a cause acting from within—viz., muscular contractility, acting alone; but in the vast majority of cases of broken bones these two causes will be found acting in conjunction. Thus, as examples of *direct* and uncomplicated external violence, I may cite a blow or a fall crushing in or shattering the cranium, or a gunshot projectile impinging directly upon a bone. Of *indirect* violence, fracture of the clavicle by a fall upon the shoulder, of the lower end of the radius by projecting the hands to save the face in falling forward, or of the thigh by the leverage of the body in falls upon the feet, as in jumping from a carriage in motion. In the latter the amount of participation of the powerful muscles of the thigh in aiding the fracture would be difficult to estimate; but, where the patella is broken across in the act of kicking a foot-ball, or the olecranon fractured by the triceps extensor cubiti in striking from the shoulder, there is little room for doubt as to the unaided influence of the muscular effort.

All the bones of the skeleton are liable to be broken, but fractures of the bones of the limbs are by far the most frequent. In over 13,000 fractures tabulated by Gürlt, nearly 11,000 were in bones of the limbs. Of the balance, one half were of the ribs, leaving but 1,205 out of the 13,000 for the skull, vertebral column, pelvis, sternum, and scapula.* In 2,187 fractures tabulated by Norris from the records of Pennsylvania Hospital, 1,654 are of the limbs and 533 of the head and trunk, including clavicle, scapula, and pelvis.†

A fracture may be incomplete and partial, or the fragments of the broken bone may be entirely separated from each other.

* "Handbuch der Lehre v. den Knochenbrüchen," Berlin, 1865.

† "Contributions to Practical Surgery," Philadelphia, 1873, p. 143.

Among *incomplete* fractures we meet with cracks, fissures, or partial splintering of a bone; cracking or indentation of one of the tables of a flat bone without the other table being involved; crushing-in, or "impaction," of one portion of a bone into its own spongy structure; and, finally, the partial fracture of the long bones that occurs in early life, resembling that which is produced when a green hickory stick is suddenly bent upon itself. A bone may be bent or indented without any perceptible fracture, in which case it will recover its normal shape without assistance, unless the cause be persistent. It is possible that, in case of indentation, and also of impaction, the cancellated structure may be condensed by yielding of the laminæ inclosing its cancelli.

Complete fractures are described as *transverse* and *oblique*. The former are rare, and occur mainly in childhood; even then they are liable to present irregularities of surface which sometimes render coaptation difficult. Of obliquity in the direction of a fracture there is every degree of variety, from a slight deviation from a transverse line to a longitudinal split, which in a long bone may be almost or quite parallel with its axis.

The essential difference, as regards long bones, between the various degrees of obliquity in a fracture ranging between the two extremes of transverse and longitudinal, hinges upon this practical consideration: *whether by coaptation the fragments can be made to antagonize each other by means of an ordinary retentive apparatus and to maintain their position against the tendency of muscular contraction to shorten the limb; or whether they are so oblique as persistently to slip past each other, and thus necessitate the employment of a special extending force.*

A rarer variety of fracture—in some cases complete, in others incomplete—is that which is known as the *separation of an epiphysis*. Of course this lesion takes place only in early life. It may involve simple

separation through the cartilaginous bond of union that connects the epiphysis with the shaft; or, it may be in part fracture and in part simple separation; or, finally, the fracture may extend into the substance of the epiphysis, and it may also involve the shaft of the bone. I have encountered all of these varieties.

In a boy of seventeen, at St. Vincent's Hospital, whose knee had been twisted and crushed, I recognized that the lower epiphysis of the femur had been rotated upon itself so as to lie with its longest measurement antero-posteriorly, one of its lateral tuberosities projecting as a rounded bony tumor in the popliteal space.

Fractures, and, in fact, all injuries near joints in young subjects, involve the possibility of the disjunction of an epiphysis; and this circumstance should always be kept in view.

A fracture is called *simple* when a bone is broken at one point and there is no other complication; *compound*, when there is lesion of surrounding soft parts, so that the seat of the fracture communicates with the air; *comminuted*, when the broken bone presents several distinct fragments; *complicated*, when lesion of an important nerve or artery co-exists, when disease of the broken bone has existed previously, when dislocation has been produced at the same time with the fracture, or where there is a wound or any other lesion near the seat of the fracture but which does not communicate with it. When several bones are broken in different parts of the skeleton, the case is spoken of as one of *multiple fracture*.

There are certain influences which seem to favor the occurrence of fracture, generally spoken of as *predisposing causes*, concerning which we must hold intelligent opinions. It is an anatomical fact that the bones of infants and old people are more fragile, through preponderance of animal matter in one case and of bone-earth in the other, than they are in middle life. It is also to be remarked that children are both helpless and

reckless as to exposure to risk, whereas age is prudent and cautious. In advanced life the spongy portions of the bones undergo rarefaction, and in this way their strength is impaired. Professor Post tells of a case of fracture at the neck of the thigh-bone in an old gentleman caused by a fall from a piano-stool upon a soft carpet. Bones will unite readily, however, in other localities, even at the most advanced age. I know of a case at ninety-two, and of another old gentleman with a fracture of the fore-arm at ninety-seven.

Fracture occurs sometimes *in utero*, and unites, unless subjected to too much motion; it is also liable to be produced, through rough handling of the fœtus, in obstetrical manœuvers. I am free to say that, in the cases of this kind which have come under my observation, the lesions have been the result of violence, and not of muscular contraction, to which they are often ascribed.

It is a popular belief that bones break more readily in freezing weather; but this seems to be a fallacy founded upon the frequency of falls and fractures when the ground is slippery; for hospital statistics show a preponderance of cases in the more pleasant seasons, when building and out-of-door occupations involving risk are most carried on. The influence of sex in favoring the occurrence of fracture resolves itself into the necessarily greater exposure to risk on the part of the male.

As to *the effect of constitutional diseases* in predisposing to fracture, this is true only of those which affect the osseous tissue at the point at which the bone breaks. A patient under my care in the New York Hospital with cancerous disease at the knee-joint lodged a complaint against his nurse because he sustained a fracture of the thigh while he was being moved from one bed to another. The accident in this case was due to cancerous infiltration of the thigh-bone at the point broken. The fracture was treated by the simple addi-

tion of coaptation splints, for the limb was already upon a double inclined plane, and union took place in the usual time.

I have knowledge of an equally favorable result in other cases of abnormal fragility of the bones in cancer. The degeneration of quality in tissue does not seem necessarily to interfere with subsequent union. There is no positive evidence that *gout* or *syphilis* renders the bones more likely to break unless there be local disease at the point of lesion.

Rickets, a constitutional affection confined to early life, in which loss of rigidity in the skeleton is the principal manifestation, is often accountable for fracture in children, and even for intra-uterine fracture; but *the influence of this curious disease is not prolonged beyond puberty.* There are also other general conditions of the osseous system besides rachitis, vaguely indicated under the names of *mollities ossium* and *fragilitas ossium*, of which the pathology is not well understood; they seem to render certain individuals more liable to fracture, and the peculiar defect is in some cases transmissible to offspring, and may crop out at certain periods of life. French authors mention a female skeleton in the possession of Esquirol in which traces of more than two hundred fractures could be detected.

Now, it is a remarkable fact that in all these systemic dyscrasiæ which favor the occurrence of fracture, repair rarely fails, either in promptness or efficiency. This has been the result of my observation; but Erichsen holds a different opinion. He says:* "I have known a gentleman little above fifty, apparently in perfect health, break his thigh with a loud snap while turning in bed"; and adds: "in these cases union rarely takes place, or not without much difficulty." This I can not indorse.

In the causation of fracture it is necessary to conceive a distinct idea of the difference between the *direct*

* "Science and Art of Surgery," American edition, 1873, i, 303.

and the *indirect* application of the force which has produced it. The former, in which a bone is broken by force directly applied—as where a beam falls across a man's leg and breaks the bone at the point of impingement—is more likely to bruise the soft parts at the same time, or to make a wound communicating with the break in the bone, thus producing compound fracture; and it is also likely to break the bone more transversely than obliquely. Force applied indirectly—as when the leverage of the body in jumping from a vehicle violently bends the bones of the leg after the foot has been arrested by contact with the ground, the body being still surged forward by its *vis inertiæ* while the foot is held stationary—usually produces an oblique fracture, the bones giving way at their weakest point. This latter, for the tibia, is at the juncture of its lower and middle third; for the fibula, at its neck—a long inch below its upper extremity, or head, where unrecognized fracture is not very rare. But, when the tibia gives way, the fibula in most cases breaks at a corresponding point.

If the soft parts are wounded in a fracture of the leg produced in this manner, the result comes usually from perforation from within outward by the sharp extremity of the upper fragment of the tibia in an attempt to bear the weight of the body upon the broken limb.

It is not unusual for both directly and indirectly applied force to act in concert in producing fracture.

An example of fracture caused by force applied to each end of a bone so as to bend it to the point of breaking by exaggerating its normal curves was furnished by a coachman brought to the New York Hospital with both clavicles broken—what is called a "double fracture." He had been crushed by a horse against the side of his stall. This man was treated, with a good result, by simple position on his back, his arms having been pinioned immovably to his body.

Cases of fracture by muscular action alone are rare.

Such an accident is sometimes discovered after an epileptiform convulsion; but a bone may be broken in the fall that accompanies the seizure. Nevertheless, dislocation also occurs not infrequently in a paroxysm of the "falling sickness."

Gürlt has been able to collect only 133 out of 13,000 cases in which fracture was due to simple muscular contraction. Besides the patella, already mentioned, Professor Agnew mentions fracture of the os calcis as having occurred in the effort to recover the balance of the body in a threatened fall.

An omnibus driver, with fracture of the humerus at the middle of its shaft, was sent to the New York Hospital by one of the governors, who afterward told me he had witnessed the occurrence of the accident. In a violent effort to pull up his horses to avoid running over a child, the man had felt his left arm suddenly become powerless, and when he had been assisted down from his seat it was discovered that there was a false point of motion at the middle of his left arm. I recognized no predisposing cause for the fracture in this case, and the man made a good recovery in the usual time.

The *symptoms of fracture* are as follows: Consciousness of the sound or sensation of a bone breaking or giving way; local pain; loss of power in the part; swelling; deformity; contusion; ecchymosis; a false point of motion; crepitus. Of these, *a false point of motion in the continuity of a bone and the grating sound that is produced by rubbing the broken surfaces of a fractured bone against each other are the only absolutely trustworthy and characteristic symptoms of fracture.* The others are what are called "rational signs," and have only a certain relative value, inasmuch as they may co-exist with other forms of injury. The sound of snapping or breaking, when heard, and the sensation of giving way, as often felt, are very significant; but in most cases they are absent or unper-

ceived, or the evidence in regard to them is open to doubt.

Pain, when confined to a certain spot, and when intensified by pressure or by an attempt to get motion at the spot, as by an effort to bend it—if a long bone—is a sign of value; otherwise it has little meaning.

Loss of power is in most cases involuntarily simulated; a patient will not move a part recently hurt, through fear of pain, and says, and possibly believes, that he can not. Interruption of continuity in a lever, whereby the muscles attached to it can not act, is the only source of absolute loss of local power, unless, indeed, the nerves of the part be paralyzed. Thus, you may ask a patient with a fracture through the olecranon to push with his hand, when the elbow is flexed, against a fixed object, by voluntary contraction of the *triceps extensor cubiti*, and he can not, even though consciousness of pain be temporarily abolished, as by the partial effect of an anæsthetic, or in delirium tremens. In this latter condition we often see patients attempt to use a broken arm or to walk with a broken leg, showing that there is no absolute loss of power except where the bone can not be used as an unyielding lever. Ashhurst says: * "I have myself known a man with fracture of both bones of the leg to walk about the ward when under the influence of *mania a potu*, using his fracture-box as a boot, and apparently not suffering any inconvenience from his injury."

The sense of feebleness and uncertainty in walking felt by a person with a badly united fracture of the patella is a fair illustration of *partial* loss of power from fracture.

Swelling of the injured part and *contusion*, or at least *ecchymosis*—although more marked and constant in fracture from direct violence—are present in some degree in all fractures; they interfere more or less with the accuracy of the surgeon's estimate of the condition

* "Prin. and Prac. of Surgery," Philadelphia, 1871, p. 219.

of parts beneath the surface at the seat of a suspected fracture, but have little real value as symptoms, for they exist frequently when there is no fracture.

As to *deformity*, it may possibly have existed previously; or it may be due to bending of a bone, to dislocation, or to some other coincident lesion. When very characteristic—as the silver-fork deformity when the lower end of the radius is broken, or the eversion of the foot in fractures of the thigh—it is a sign of great value. I have seen the bones of the fore-arm bent at a right angle, after a fall, in a boy, and yet no mobility at the point of bending. In all these cases of bending of the long bones in young subjects there is more or less partial fracture, and I have found that they can not be restored to a good position in most cases without producing a complete fracture; and in effecting this there need be no hesitation.

Mobility at a point in the skeleton where motion should not exist normally is unmistakable evidence of fracture. If the mobility can be produced at will by the surgeon, and if, by grasping opposite portions of the suspected bone and rubbing them forcibly together, he can get the rough sensation we call *crepitus*, the evidence of recent fracture is complete.

Deformity does not necessarily accompany a broken bone: witness the frequent examples of fracture with impaction in which there is no change in shape, and in which false point of motion and crepitus are equally wanting, with little appreciable shortening. There are also rare cases in which a bone is the seat of fracture while the periosteum investing it remains intact.

When deformity or any change of shape or outline does follow immediately upon fracture, these are mainly due to the new position of the fragments of the broken bone. A sudden effusion of blood into and among the tissues and parts at the seat of injury may also play a part; but this cause of change in normal outline is distinguishable by its general softness and roundness

and the bluish tint by which the swelling is usually marked. Deformity in fracture arising from the position and relation to each other of the fragments is more important. This may have been produced directly by the fracturing force, as when the skull is driven in by a blow causing fracture with depression; or by the efforts of the patient to help himself, as by trying to walk, after a fracture of both bones of the leg, where a sharp fragment is liable to be thrust through the skin; or of the fibula near the ankle. This latter injury has been called *Pott's fracture*, after the famous English surgeon who was himself a victim of the accident. Having frequently witnessed cases in which this injury had been aggravated by attempts to use the limb under the idea that the accident was merely a sprain, the great surgeon is said to have lain quietly where he fell until the bystanders, under his direction, had brought a shutter, upon which he was conveyed home without any effort whatever on his own part.

As in the common "silver-fork" fracture at the lower end of the radius, the position of the fragments causing the deformity often results from their "impaction." This classical form of injury, which shares with fracture of the clavicle the distinction of being the most common of all fractures, is produced in most cases by the involuntary thrusting forth of one or both hands to protect the face while falling head foremost, so that the weight of the body is received upon the outstretched palm.

In a patient brought to the New York Hospital who had fallen headlong through an open hatchway into the hold of a ship, I found a double silver-fork fracture, i. e., one at the lower end of each radius. But the attempt at protection offered by the outstretched palms had not proved sufficient, for there was also a fatal fracture of the skull, and a fracture of the thigh besides. I made a careful dissection of the fractures near the wrists, verifying the existence of impaction and immo-

bility in both of them; and this I am satisfied is the rule. The absence of crepitus in this fracture—a consequence of the impaction—explains why it so often passes unrecognized as a simple sprain.

But by far the commonest cause of deformity in recent fracture arises from the action—voluntary or involuntary—of the muscles which act upon the fragments of a broken bone. In fracture of the thigh at its middle, the characteristic deformity is exaggeration of its normal anterior convexity with shortening, sometimes to the extent of three or four inches, and marked increase of its circumference. These latter features are caused by the simultaneous contraction of all its muscles, by which the fragments are forced to slip past each other at the point of fracture and to overlap. This tendency to shortening is due not only to the excited "tonic contractility" of the muscles by the approximation of their points of attachment, but there is increased stimulation to irregular spasmodic contraction by mechanical irritation from contact often of rough and sharp fragments and splinters, which may lacerate both muscles and nerves. It is apparent that an accurate familiarity with the points of attachment of the muscles, as well as with their physiological action, is of great value in order to enable the surgeon to overcome deformity from this source, and to treat fractures to the best advantage.

Again, the weight of that portion of a limb which is deprived of its natural support by the breaking of a principal bone is a frequent cause of deformity. Thus the tendency of the heel to sag down in fracture of both bones of the leg, causing anterior convexity, is a feature that requires constant efforts to antagonize it by adequate support to the foot. In fractures of the shaft of the femur there is a similar tendency in the foot to roll outward, which requires especial attention. These are the deformities which most frequently follow fractures of the leg and thigh; and the surgeon

is expected, by his means of treatment, to counteract them.

The *diagnosis* of fracture requires at the hands of the practitioner not only a familiarity with the topics we have touched upon, but it demands, also, careful and intelligent manipulation.

In a case of gravity, symptoms of shock are to be properly met. All the *rational* signs of fracture are to be taken into account and estimated at their just value; and the *absolute* signs are to be sought for with accurate but gentle scrutiny.

In the localities at which impacted fracture is liable to occur—the upper extremity of the femur and lower end of the radius—no violence is to be employed, especially in the former, in seeking for a false point of motion and crepitus. In the latter, if the characteristic silver-fork deformity be present in ever so slight a degree, the existence of fracture may be safely assumed, and it should be reduced at once, most advantageously under an anæsthetic. In case of suspected fracture of the femur near the hip-joint, where the absolute signs are wanting, the bony prominences or landmarks should be studied. Where the diagnosis is doubtful, or there is a question of impacted fracture, the case should be treated by rest alone, the limb being secured by the simplest means—such as sand-bags—and the result awaited, with equal care that the function of the limb is not needlessly lost, nor the patient, if aged, rendered bedridden.

The difficulty that sometimes attends the diagnosis of fractures near the hip is illustrated by examples not rarely recorded. Norris * reports a case which occurred in the Pennsylvania Hospital: A man of fifty-two was admitted for an injury of the hip received by falling down a few steps. He complained of excessive pain about the joint, and was unable to rise, or to move the limb. Accurate measurement showed the limb to be

* In his "Contributions to Surgical Pathology," p. 135.

of the same length as that of the opposite side. No deformity existed about the joint, no crepitus could be detected, and the toes were not thrown outward. The injury was looked upon as a contusion, and rest, with a few cups, were the remedies prescribed. On the fifth day after admission the patient had an attack of *mania a potu*, and during his delirium was out of bed, and stood upon and moved his limb considerably. Having recovered from this attack, he was sent back to the surgical ward, and "it was then found that the limb was shortened a full inch and a half and the knee and the toes everted, though a daily examination of the part up to the time of this attack showed nothing amiss about it. The case was now ascertained to be a fracture through the great trochanter." Cases similar to this are not very rare in hospital practice; and they occur also in private. A delicate, spare lady, of sixty-four, fell from a first-floor window upon the sod in attempting to fasten back a shutter, and was found complaining mainly of a sprained ankle, and also of a slight bruise of the hip. She was carefully examined for fracture at the hip by her attending physician, a man of skill and experience, and no deformity detected. The patient kept her bed for six weeks, and then gradually got about on crutches, but, not improving as to her lameness, came to the city after some months, seeking advice for a "tumor of the hip," which gave her uneasiness. I found the "tumor," and it proved to be nothing more nor less than the great trochanter of the femur nearly two inches above its proper position. But the limb could be readily elongated by traction on the foot, when the trochanter was found in its proper position, and, when rotated, crepitus was distinctly felt. An impacted fracture had evidently occurred at the time of the accident, and, failing to unite, had become unlocked and capable of yielding crepitus. In these cases subsequent early examinations should always be repeated if lameness continues.

In the diagnosis of fracture, *anæsthesia* is often a most valuable resource; the absence of outcry allows full play to the perceptive powers of the surgeon, and the abolition of muscular contraction leaves the fragments in apposition and ready to yield crepitus. It also greatly facilitates their accurate adjustment and the discovery, at the same time, of causes which may tend to keep up deformity. The great advantages gained in the diagnosis and treatment of a fractured thigh in a paraplegic patient was long ago observed and set forth by Desault. Now we are able, by means of ether or chloroform, to render the muscles powerless at our pleasure.

In fracture near a joint, and especially when it is possible that luxation may co-exist, the use of an anæsthetic is indispensable, for by its aid the dislocated bone may be reduced, in most cases, by direct manipulation.

In fracture complicated with wound, gentle exploration with the finger will determine if the fragments are within reach; but before its introduction into a recent wound the nail should be cleaned, and the finger scrupulously washed with carbolic acid and anointed with vaseline.

Before considering the *prognosis* of fracture we must be familiar with nature's resources for the repair of a broken bone, and must have gained a definite idea of the changes which will take place at the seat of injury, and of the time they will probably occupy. Indeed, you are already familiar with these, for they are simply identical, except in one or two points, with the changes you have already studied in connection with the process of union in wounds of the soft tissues. We may observe at once that, in consequence of the recovery of so large a proportion of cases of simple fracture, the opportunities for recognizing with accuracy what takes place at the seat of a fracture in the human body are not frequent, and therefore the process of union in

bones has been studied in the lower animals by many of the old masters in surgery, and is still a subject of careful observation and experiment in surgical laboratories, so that it may be pretty accurately described.

In the first place, blood in variable quantity is poured out between and around the fragments of a broken bone by ruptured and lacerated blood-vessels. This escape of blood is succeeded, as in a wound of the soft parts, by a flow of liquid exudation. As a rule, the effused blood is dissolved by the liquid exudation and carried off by the lymphatic vessels; in fact, we often see it staining the surface of a limb, green and yellow, weeks afterward. Here, as in a flesh-wound, the blood is of little service in forming a bond of union; and, when the amount is large, it may be a positive hindrance to repair.

On the whole, it may be stated that the firm and somewhat translucent jelly-like mass of plastic lymph which has formed in simple fracture, before the end of the second week, around the fragments of the broken bone, if they have been kept moderately quiet, presents simply a reddish or rosy tint; and this is due as much to the loops of newly formed capillaries within it as to color derived from blood-clot.

The source of the exudation which has deposited this bed of plastic lymph *is the blood-vessels of all the tissues around the seat of fracture*—of the periosteum, connective tissue, contiguous muscles, and, later, of the bone itself.*

It was formerly taught that the ensheathing mass of reparative material, so promptly thrown around the ends of a broken bone, was furnished exclusively by the periosteum; but this is only true in those rare cases in which a bone is broken without any accompanying lesion of its periosteum. In all other cases the mass of plastic lymph is derived from exudation furnished by

* Gosselin, "Clinique chirurgicale de l'hôpital de la charité," 1873, t. i, p. 374.

all the surrounding tissues in exact proportion to the richness of their vascular supply and their promptness in taking on the reparative effort. As late as 1867, Ollier * brought forward arguments in favor of the old doctrine that it is the special office of the periosteum to furnish the material for bone repair; but his views have been controverted by Valette,† Gosselin,‡ Henri Müller, and Ranvier. Ollier has himself shown by experiment # that the tibia of a rabbit, completely stripped of its periosteum and fractured, united very well, although more slowly than usual; and that in this case consolidation was effected by an ensheathing mass of peripheral callus. On section of the bone, restoration of the medullary canal, which had been previously filled with callus, was found going on in its interior; and *the callus was invested externally by a new layer of thick periosteum.*

The broken surface of the bone itself is the last of all the tissues injured in a fracture to show any evidence of change for the purpose of repair; but after the fourth week its Haversian canals will be found distinctly enlarged and their contained vessels in a state of corresponding distention, giving the bone a perceptible redness, and presenting anatomical characteristics of what Gosselin has called "plastic," or "non-suppurating osteitis." The exudation from these vessels furnishes the bed in which the bony bond of union is ultimately formed *between the fractured surfaces themselves*—and this is now called *interfragmentary callus.* Its formation, always slow—rarely, in fact, complete before the sixth month after the fracture—is more or less perfect according to the exactness of apposition between the fragments and the success attained by the treatment in preventing motion.

* "Traité expérimental et clinique de la régénération des os, et de la production artificielle du tissu osseux," Paris, 8vo.

† "Nouveau dictionnaire de méd. et chir.," t. xv, p. 445.

‡ *Op. sup. cit.*

Op. cit., t. i, p. 220.

The reason why the work of repair goes on so much more slowly in the compact tissue of bone is the necessity of absorption of the walls of the Haversian canals for the purpose of accommodating their capacity to that of their contained blood-vessels, which are enlarging under the stimulus of injury; and this requires time. When the Haversian canals become thus widened, the affected bony tissue is consequently rarefied, and its interior surfaces become covered with plastic lymph furnished by the distended vessels; and this plastic lymph is presently organized into a granulating surface which goes on to grow, and eventually undergoes ossification.

In a compound fracture, where the parts are exposed to the air, this process is accompanied by suppuration; in a simple fracture, where the conversion of granulations into connective tissue, and subsequently into bone, goes on *subcutaneously*, there is no pus formation, and the process is therefore all the more promptly and perfectly accomplished.

The *exterior ensheathing* mass of plastic lymph, derived from the exudation from the surrounding soft parts, undergoes, on the other hand, the successive changes into connective tissue, fibro-cartilage, and ultimately into bone, with comparative rapidity. According to Billroth,* the cells of embryonic neoplasm—what we have called granulation tissue, the first stage of callus—may develop either directly into bone, or first into cartilage and then into bone. In rabbits, forming callus undergoes transformation into cartilage before it ossifies; and the same is true in children. In adult dogs, callus is formed by ossification directly from embryonic or young connective tissue without any intermediate cartilaginous stage; *this is also true in the adult human being.*

Only about six weeks are required for the process of formation of ensheathing callus in an adult with ordi-

* "Pathol. chirurg.," Paris, 1868, p. 220.

nary simple fracture; in a child, half this time; in old age, an additional week or two; but for compound fractures a much longer period is necessary—generally from three to six months.

This newly formed bony tissue called callus, generated for the sole object of consolidating the breach of continuity in bone, presents a greater bulk where fragments override each other, or where comminution or too much motion is present in addition to defective coaptation; it is invariably less in quantity in proportion to the exact apposition of broken surfaces and the degree of immobility secured. It was first taught by Dupuytren, and since by French and English authorities, until recently, that the external sheath of callus by which the ends of a fractured bone are molded together is only a temporary formation, and it has been therefore styled "provisional callus." The bony matter formed later between the fractured surfaces, and designated, in accordance with this view, "definitive callus," was regarded as the true and permanent bond of union. In proportion as the latter was perfected in its organization it was assumed that the provisional callus disappeared by absorption. This is not believed by the latest authorities in surgical pathology. It has been gradually demonstrated that although ensheathing callus does diminish in many cases, apparently under the influence of muscular attrition, as when seated, for example, on the anterior convexity of a badly coaptated thigh-bone, yet it will remain unchanged along the concavity of the same bone, where its support is most needed; and that, *as a rule, it does not disappear, but may shrink in bulk and become more dense in structure.**

* According to Billroth (*op. cit.*, 1868, p. 214), "callus undergoes change by absorption and removal of that which is formed in the medullary cavity, and by the disappearance, also, of a large proportion of the external sheath." Valette says ("Nouv. dict.," 1872, art. "Fractures"): "Callus may undergo change in external form by friction of

In the medullary canal in long bones, and in the cancelli of spongy bones where plastic lymph accumulates just as it does between the fractured surfaces and externally, the fat-cells of the marrow disappear as cell germination begins; and the resulting embryonic tissue goes on to develop into bone so as to form an *internal pin or splint* by which the fracture is additionally supported. This change takes place early and promptly, at the same time with the formation of the external sheath; it is not slow in forming, like the inter-fragmentary callus; nor, as a rule, is it ultimately absorbed, except, perhaps, where the fragments have been very accurately coaptated.

The appearances presented externally by a broken limb at the bedside, while the changes just noted are going on at the seat of injury, may be described as follows: During the first week or ten days, according to the site of the fracture, the size of the broken bone, and the severity of the accident, ecchymosis, swelling—both œdematous and attended by redness—local heat with tensive pain, and more or less traumatic fever, are likely to occur. With the ecchymosis, usually—sometimes when it is absent—water-blisters, or phlyctænæ, filled with bloody serum, often make their appearance; and these, to the inexperienced eye, look like harbingers of gangrene. These symptoms come on within a day or two, and the swollen and sensitive condition of the parts tends to make the diagnosis as to the absolute signs of fracture somewhat less simple; the sooner after the accident, therefore, that a patient with a broken limb is seen and examined, the better.

neighboring parts, as in the case of bone; but, once formed, it is never absorbed, as was formerly supposed" (p. 446). Gosselin asserts (*op. cit.*, 1873, p. 43) that "we can no longer employ the terms 'provisional' and 'definitive' as applied to callus. . . . The most we can say with truth is that the callus is perhaps more voluminous to-day than it will be six months hence. . . . But the ideas of Dupüytren and Meischer are certainly not applicable to cases of fracture in which the fragments are held during union in accurate contact."

This is usually spoken of as the "inflammatory period." In a simple fracture produced by indirect violence the reactionary excitement is usually very moderate. Where there has been direct violence causing a wound at the seat of injury, and where the fracture is compound, inflammation is often more severe and prolonged. In the latter case the traumatic fever may merge into septicæmia and pyæmia, and the phenomena of repair remain in abeyance.

In the great majority of cases, however, the appearances and symptoms I have described gradually subside, and toward the end of the second week quiet and comparatively painless reparation has been established. By this time the plastic lymph has become fairly organized, and its conversion into bony callus has begun to take place.

This *second* period in the progress of a simple uncomplicated case lasts from two to four weeks, and at its termination the fracture will be found, as a rule, to have become solid—i. e., in surgical language, to have "united." Union is said to have taken place when, the bone having been grasped firmly above and below and an attempt made to bend it at the seat of the recent fracture, the false point of motion is found to have disappeared.

During the *third* period—i. e., from the sixth week to the end of the sixth month—the inter-fragmentary or definitive callus is perfected, and the external or ensheathing callus may possibly shrink and become more dense. Early in this period—that is, during the first few weeks after union has taken place—the surgeon will often recognize as clinical features more or less rigidity of neighboring joints, especially of the articulation nearest the seat of fracture; difficulty in the free gliding of tendons in their sheaths from partial adhesion caused by pressure of splints and bandages, and prolonged suspension of function from immobility; perhaps obliteration of surface-veins and partial œdema;

sometimes surface eschars, and always a certain amount of muscular atrophy.*

Fractures which extend into a joint involve danger of delay, or defect in union. When the patella is broken transversely, there is often wide separation of the fragments through the concentrated action of powerful muscles upon the upper one, and it is not easy to command their apposition. Even when this is accomplished, union is in most cases defective. Can the presence and contact of synovial fluid retard cell generation as the presence of blood does? Is it true that the liquid exudation escapes into the cavity of the joint instead of accumulating around the fragments, and that the resulting plastic lymph is consequently defective in quantity and quality? Gosselin suggests this as the probable explanation of failure of union in intra-capsular fractures of the neck of the femur and of the humerus.†

The invasion of the cavity of a joint by fracture may cause synovitis, or simply plastic exudation with subsequent rigidity and lameness from false ankylosis. It is to be remembered that the necessary immobility of a joint imposed by certain forms of apparatus used in the treatment of fracture is competent to produce these same results. But *the most remarkable result that follows fracture communicating with an articulation is failure of union in the fracture*, such as occurs not infrequently at the neck of the femur, even after judicious treatment, and in early life.

A young man was brought to the New York Hospital with well-marked symptoms of fracture of the neck of the femur. He had been dancing under excitement, and accidentally fell, striking heavily on the trochanter. He was kept in a straight splint for several months in the service of the late Kearny Rodgers. No union

* Gosselin asserts that the muscular atrophy from pressure and non-use that succeeds fracture never entirely disappears. *Op. cit.*

† *Op. cit.*

having been obtained, he was finally allowed to get about on crutches, and soon left the hospital. Within the year after the accident this young man was again admitted in a very bad general condition, attributed to irregular habits, with a fluctuating swelling at the seat of the ununited fracture. He subsequently became hectic, and died under my care. On examination I found the cavity of the hip-joint full of pus, and, like the surrounding structures, very much altered. The head and part of the neck of the femur, perfectly dead and free from all attachments, lay loose in the cavity. There had been an oblique fracture through the neck of the femur, partly within and partly without the line of attachment of the capsule of the joint. A distinct smooth groove existed on the surface of the portion of the neck which still projected from the trochanter, and this groove had evidently been worn by constant friction against a sharp projecting angle of the dead fragment in efforts to use the limb.

In *compound fracture* the existence of an open wound of the soft parts, by which the fragments of the broken bone are brought into communication with the external air, renders healing by way of suppuration a necessity, unless the wound be promptly closed. The same differences as to promptness and safety of repair which we have already recognized between a subcutaneous and an open wound are present here to explain why a compound fracture is so vastly more dangerous to life than a simple fracture. But it does not follow that all parts of the injured and exposed surfaces in a compound fracture necessarily suppurate; in the deeper portions of the wound, where the bones usually lie, suppuration, under favorable circumstances, may be escaped, and healing take place as in a simple fracture. Hence the great advantage to be gained by securing primary union of the soft parts whenever this is possible; for *just exactly in proportion as this desirable intention can be accomplished, the delay and danger*

that attend upon suppuration in bone will be escaped. The slowness and difficulty with which the bony tissue takes on repair are rendered more slow and difficult when the parts are exposed to the external air, because *the waste involved in suppuration delays the process.* The bony callus, by means of which alone the fracture can unite, is to be developed out of the granulations which must have previously covered all the surfaces of the broken bone.

Again, a compound fracture, especially when produced by direct violence, often presents very much the same characteristics as a contused wound. One of these is the necessity of getting rid of those portions of the tissue killed by the bruising before beginning to repair. Bone is very easily deprived of life, and, when a portion of it has been thus killed, a long time is required for it to separate and be thrown off by the still living surface. This is shown by the fact that the living surface from which a mass of dead bone has separated in this manner is always found covered with granulations. Until bone killed under these circumstances has been thrown off, the granulations themselves do not usually begin to develop into bone—although, in exceptional cases, we find a fragment of dead bone surrounded and shut in by an exuberant growth of callus: this is simply an exception that proves the rule. Here, then, is another source of delay and danger liable to complicate a compound fracture.

It follows from these considerations that there are several distinct varieties of compound fracture, and, in fact, these are readily recognized in clinical experience. In the first place, primary union of the wound in the soft parts is secured in a certain proportion of cases, usually by the prompt and judicious action of the surgeon. These occur most frequently, perhaps, in oblique fracture of the bones of the leg from indirect violence, where the wound has been produced by perforation of the skin from within by the point of a sharp fragment.

When primary union has been thus attained, the subsequent progress of the case is narrowed down to that of a simple fracture.

Then there is a large percentage of cases in which *partial* primary union of the soft parts may have been obtained, a certain portion of the wound, larger or smaller, being left to granulate and suppurate. Here the fever at first and the earlier accompanying symptoms are mild. There is little appearance of danger, but the case drags on for three or four months of constant but moderate suppuration before there is any union. Perhaps, at about three months, a sequestrum, which has heretofore shown a bare white surface, becomes loose, and, on being removed, a layer of granulations covering the bone beneath comes into view, and then union soon follows. The length of time required for the separation of a sequestrum is in proportion to its size and extent of surface. Such cases as these, which would be likely to occur in ordinarily healthy subjects in private practice, or in the country, get well, for the most part, between the fourth and the sixth months.

Finally, we have a category of grave cases of compound fracture, of which a large proportion terminate unfortunately, where no primary union has taken place or maintained itself, and where, in consequence, all the wounded surfaces, whether of bone or soft parts, have fallen ultimately into suppuration. Cases of this class occur in unhealthy subjects: in drinking men, who often become victims of *delirium tremens*, when the best management may fail to retain a fracture in position; and in patients in large hospitals, where they are more exposed to the poisons of erysipelas and pyæmia. Here suppuration is liable to involve the walls of large and irregular cavities around the fragments—cavities with deep recesses and prolongations, where dead and dying tissues may be retained, and pus stagnates for want of a free outlet; where the limiting barrier of

healthy granulations is liable to melt away and consequent burrowing of pus to take place, and where sulphureted hydrogen and, still worse, septic virus may be generated and absorbed into the blood.

In connection with the study of the process of repair in fracture, certain accidents are to be noted as liable to delay or interfere with its favorable progress. Among them I may mention nervous delirium, retention of urine, hæmorrhage, muscular spasms, delirium tremens, emphysema, thrombosis and embolism, osteo-myelitis, diabetes, and albuminuria; to these should be added the possible occurrence of fracture in a bone already diseased, and, as not uncommon, of abscess, necrosis, or gangrene. Most of these subjects are treated of elsewhere, but some of them require a word of notice here.

Emphysema may occur in connection with a fractured rib from penetration of the lung substance by a sharp fragment, and it may travel extensively over the surface of the body; as a complication, it is singularly harmless in this form, and usually subsides, without treatment, by absorption of the air. But a sensation of crackling in a limb may become perceptible within a day or two after a fracture (e. g., by crushing), accompanied by tumefaction of the whole segment of the limb and a tawny, marbled appearance of its external surface, which is of graver import and suggestive of gangrene.

Thrombosis and embolism, notably the fatty embolism of Czerny, play their part in explaining mysterious causes of sudden death after fracture.

The surgeon should never neglect examining the urine of a patient with a broken limb. The discovery of albumin, of tube-casts, or of sugar, would possess for him a grave significance. Although not incompatible with union in the usual period, the existence of either of these conditions would suggest a guarded prognosis and persistent watchfulness.

Most surgical authorities include *inflammation*

among the complications of fracture. It is certainly present in some degree in fracture, as in every other lesion, as the essential element in the process of repair. If destruction of tissue occurs coincidently with its presence, this is to be attributed to the nature and extent of the injury, or to lack of reparative power in the injured organism.

The *prognosis* in fracture may be inferred in a great degree from what has been already said, but I will add a few words by way of summing up. Fracture is less dangerous when simple than when compound; in the young than in the old; in the shaft of a long bone than in one of its extremities; when produced by indirect than by direct violence; when transverse than when oblique. Fractures of the bones of the limbs are less dangerous than those of the trunk, in view of the greater liability of the latter to visceral complication. It is worthy of remark that multiple fractures do not proportionally render the prognosis more serious, either as to failure of union or delay in its accomplishment. Finally, the health of the patient previously and at the time of the accident, as well as the period of life, and also the facilities afforded for adequate care in treatment, materially influence the result in every case of fracture, and must be included in a judicious prognosis.

It has been truly said that the principles of surgery relating to the *treatment* of fractures are simple, but that the practice is often very difficult. Every case of fracture presents the following general indications as to its treatment: (1) to restore the fragments to their normal relations; (2) to keep them quiet in a proper position until union is accomplished; (3) to meet complications as they arise.

At the time of the accident there is necessity for care that no aggravation results from the efforts of the patient to help himself before realizing the extent of his disability, as we have seen, or from the unwise handling of bystanders; especially that a simple frac-

ture is not rendered compound by an attempt to bear the weight of the body upon a broken limb. Hæmorrhage, if present, is to be temporarily controlled by compress and bandage, or by tourniquet. Rough splints may be extemporized out of materials at hand, or a limb may be temporarily enveloped by a soft pillow, fortified externally by something more solid to limit motion while the patient is being carried, if necessary, on a stretcher, or even upon a window-shutter or a door, to his bed.

The best bed for a case of fracture consists of a narrow iron bedstead, in which the patient can be reached from either side; a good even hair mattress, not too elastic, and a rather low pillow. The mattress may require to be perforated to provide for defecation, although, with an efficient nurse and a properly shaped bed-pan, this is preferably dispensed with.

After shock, when present, has subsided, the clothing should be gently removed and the part subjected to examination; and, as it is desirable that this process should not be repeated, either by the surgeon or his assistants, this first formal examination should be carefully and thoroughly made.

The points to be made out are: the exact site, nature, and direction of the fracture, and especially any tendency to deformity, or any complication offering special indications for treatment. If compound, the finger in the wound is a valuable aid.

After the examination, if there be no counter-indication, the fracture should be at once reduced, or set, and an appropriate dressing applied. In the language of Pott, "a broken bone can not be too soon put to rights." The terms *reduction* and its popular synonym "setting," applied to broken bones, mean *placing the fragments in accurate apposition for healing*—implying, also, that they are kept in apposition by proper retentive apparatus. When a fracture is oblique and the fragments tend to slip past each other under the

influence of muscular contraction, extension should be made by an assistant—in the case of the thigh, for example—by grasping the foot and ankle and drawing gently but forcibly upon the limb, perhaps rotating it, as the surgeon may direct, in order to elicit crepitus. When this has been effected, and after the surgeon has completed his examination, it is a great advantage to the patient, when there is no good reason for delay, that the fracture be set forthwith.

In the case of a *transverse* fracture the coaptation is easily maintained, for the face to face relation of the two surfaces resists effectually the contractile efforts of the muscles, which now tend to keep them more closely in contact. But in an *oblique* fracture there is an obvious necessity for keeping up permanent traction upon the limb during the process of union in order to prevent, or at least diminish, the tendency to shortening. This is technically called making extension and counter-extension.

There is sometimes also a tendency to deformity from bad position of fragments, which may defy all efforts in the way of traction, aided by manipulation, to remove it. The means at our command to accomplish this end will be considered hereafter.

If slow reaction from shock should defer a formal examination, the interval should be employed in getting together the materials for putting up the fracture at once.

In setting a fracture in a limb, the corresponding uninjured member is to be taken as a guide as to shape and length ; but inquiry should be made, in view of its possibility, as to pre-existing deformity from previous fracture, or other cause, in either of the limbs.

It is a good rule that no dressings applied in fracture for the purpose of retention should cover the seat of the injury or conceal it from view ; they should leave the point of fracture open to inspection. Of course this does not apply to an evaporating lotion or a bladder of

30

crushed ice applied for the purpose of limiting vascular action. But there are many cases of simple fracture in which this rule may be disregarded and the limb incased at once in an immovable sheath ; and even here a window may be contrived so as to keep the seat of fracture in view at will.

In regard to the means at our command for securing immobility of the fragments of a fractured bone, it may be said at the outset that the simpler they are the better. Splints and bandages constitute the elements of all the contrivances for this purpose. All the mechanical apparatus in use for the treatment of fractures are modifications of these. But the necessary rigidity of the splint and the constriction of the bandage by which it is maintained in contact with the broken limb are always more or less hurtful to the intervening sensitive soft parts.

The best materials for splints are those which possess sufficient strength with the least weight or bulk. Wood, sheet-iron, perforated sheet-zinc, wire gauze, gutta-percha, pasteboard, sole-leather, prepared felt, are the materials most in use at the present day. Wood is glued in narrow strips to flexible leather (Bell's splint), and is variously carved and shaped, and also combined with metal in compound splints, devised to suit the requirements of special fractures, and for the most part bearing the names of their inventors.

Simple thin strips of whitewood, three to five inches in width by one eighth to one quarter of an inch in thickness, flat, or slightly hollowed out, are convenient to keep on hand for first dressings.

In the employment of splints it must be recognized that their use is to give unyielding firmness to the retentive dressing of a fracture, and that they are not to be used to correct a special deformity, as by exerting direct and immediate pressure upon a prominent fragment.

It has long been considered a desideratum by sur-

geons to find a suitable substance with which bandages can be saturated so as to render them unyielding when dried, and fit substitutes for splints. Of these the following substances have been employed with more or less success, and some of them have enjoyed great popularity — for the most part temporary: A mixture of white of egg and chalk was largely used on the authority of the elder Larrey; glue was advocated by De Morgan; starch by Seutin, at one time surgeon-general of the Belgian army; dextrine by Velpeau; plaster of Paris and other varieties of gypsum by the German surgeons; and, more recently, the silicates of potash, and soda. The latter seem to be gaining in favor at present; the solution dries rapidly, and makes a light and firm casing. Bandages prepared and applied in this way constitute what is called an "immovable apparatus."

The advantage claimed for this mode of dressing is its lightness—in most forms—and the ease and safety as to disturbance of fragments, in consequence of which patients may, in many cases, move about on crutches and take the air, thus avoiding the bad influence of the confinement necessitated by the more cumbrous dressings. Against it the objections have been urged that it covers up recently injured parts too entirely to be safe for general use; that it is inapplicable to compound fractures; also that it is incompatible with efficient extension and counter-extension, and therefore not suited to oblique fractures of the thigh. It is claimed in this latter case that, if the immovable apparatus be applied while the limb is in full extension, the uniform pressure of the rigid casing of the limb may be relied upon to keep the fragments in proper trelation; but this reliance has been found in practice to have little or no substantial basis, for the compressed limb in a few days diminishes in size, and the consequent lack of uniform firm support permits the fragments to ride over each other: hence the result is too often a permanent shortening of the limb.

For bandages, the best material for ordinary use is unbleached and unsized cotton cloth with a firm web and a round, even thread, not flimsy in quality; for use in special cases, flannel may be preferable; for the plaster-of-Paris apparatus, the tissue of looser web known as "screen-cloth" is employed by preference.

The elaborate dressings of old-time surgery have been pretty much abandoned, but the skillful application of a roller bandage is still a necessity. Especially is it necessary to cultivate good judgment as to the degree of constricting force that may be employed with safety in putting up fractures, which is often over-estimated. Of this the instances of eschar and gangrene from its injudicious employment, so frequent in the records of practice, and, unfortunately, also in the records of trials at law for damages for malpractice, are unpleasant evidences. In opposition to the traditional influence in favor of heavy dressings this is a good rule to adopt: *never apply a bandage unless to meet some clear indication for its use.* Again, in view of the frequency of this cause of gangrene, *never apply a bandage to a limb beneath splints.*

As has been already remarked of splints, a bandage is not to be employed to force an unruly or projecting fragment into place; this is to be accomplished by special means. The bandage, it must be remembered, is a purely retentive agent. When a limb is bandaged, the ends of the toes or fingers should always be left exposed to view, so that the surgeon may assure himself that the circulation has not been interrupted. When from their discoloration or coldness any doubt arises, the bandage should be at once reapplied with less constricting force. In short, *circular constriction by bandages is always to be guarded against.*

All splints and firm appliances must be padded. For this purpose, and for compresses, woolen blanketing, carded wool, cotton (in the form of wool, wadding, or batting), picked lint, the looser fabrics of felt, and

prepared oakum, are employed. Pads are stuffed with wool or fine curled hair. Bran, sawdust, unground flaxseed, and chaff of grain are used for the same purpose. As a temporary dressing, limbs have often been imbedded in these substances in fracture-boxes, without intervening bandages, to secure the advantages of *safe and equable pressure* which can be thus safely brought to bear upon them. Bags filled with sand can be readily molded to parts, and, by their weight, serve the double purpose of splints and compresses. Water offers great advantages for pads and cushions, as it diffuses pressure so equably; but facilities for its ready application, except in the form of the water-bed, are yet to be attained.

In applying any apparatus for fracture, all irregularities of surface of the body should be carefully filled up and rendered even, and bony prominences, like the malleoli at the ankle, surrounded by padding to save them from undue pressure. The favor enjoyed by the fracture apparatus of Burgraeve, of Ghent, in which the limb is enveloped by cotton, is due to the fact that it fulfills this indication so perfectly. The liberal use of cotton batting by M. Alphonse Guérin, of the Hôtel Dieu, of Paris, as an antiseptic dressing for wounds, has developed the additional fact that the uniform temperature at which it preserves injured parts adds greatly to its value in promoting the process of repair. In the treatment of broken bones in the insane, in delirium tremens, and in military surgery for ambulance transportation, there is no dressing better than Guérin's *appareil ouaté*, which, when properly applied, constitutes a very perfect protection.

It is a received canon of surgery that fractures should be put up permanently at once, if possible, because this course involves least disturbance of parts, and, consequently, least hindrance to prompt repair.

The exceptions to this rule are: when the surgeon has not seen the case until some time has elapsed, and

swelling has come on; when effusion of blood at the seat of a simple fracture is very considerable; or when, in a compound fracture, its complications, or the extent of the injury itself, may be so great as to raise a question of excision or of amputation. Under these circumstances temporary dressing only is advisable.

It is the habit of many good surgeons to employ temporary dressing in all serious cases until the so-called period of inflammation has passed, and then to put up the fracture more permanently. It is argued that this course involves less risk of being compelled, possibly, to remove a more elaborate apparatus, that it affords time to study the requirements of the case, and to select the best method for more permanent retention.

On the other hand, practice teaches, according to my experience, that, where prompt immobility is attained, the danger of what we call "inflammation" is reduced to a minimum, and there is good authority for the immediate application of an immovable apparatus as a rule. (Erichsen.)

Besides splints and bandages, and their endless modifications in the form of fracture apparatus, there are other means at our command to maintain the fragments of a broken bone in accurate adjustment. The first and most important of these is *position*—as by placing the articulations next to a broken bone in such an attitude of flexion or extension as to do away with the disturbing influence of the muscles attached to, and liable to act upon, either fragment.

We have examples of the benefit to be derived from position in the usual mode of treating fracture of the patella, where the knee-joint is extended and the hip-joint flexed, for the purpose of approximating the fragments by relaxing the powerful *quadriceps extensor cruris*—one of the heads of which, the rectus, takes its origin from the pelvis. Also, in the corresponding fracture in the upper extremity—that of the olecranon process of the ulna, which is put up with the

elbow-joint fully extended, in order to get rid of the contractile power of the *triceps extensor cubiti.* When the coronoid process of the ulna has been torn off, the fore-arm is flexed in order to relax the *brachialis anticus;* and in fracture of the shaft of the radius the same position is adopted, in order to neutralize the action of the *biceps flexor cubiti.*

The English surgeon Pott inaugurated an epoch in this department of surgery, in 1768, by advocating the treatment of fractures of the shaft of the femur by position alone—viz., by placing the limb on its outer side with the thigh flexed on the pelvis, and the leg on the thigh, and employing no retentive apparatus whatever. His patients escaped, indeed, the cruel extension, advocated in Paris by Boyer, by means of a long, straight splint with a screw attached, which bears his name; but they recovered almost invariably with permanent shortening of the limb, and deformity by eversion of the foot.

Pott's treatment by position alone was, therefore, gradually merged into the double inclined plane, a device which retained its principal feature—namely, the double flexure of the limb. This apparatus, as modified by Amesbury and by McIntyre, enjoyed great popularity for many years. The foot-piece in all these double inclined planes prevented rotation outward of the lower part of the limb, but permanent shortening, with exaggerated anterior convexity of the femur, was a common result.

The comfort secured by the "physiological treatment," as it was styled by its advocates, was its principal advantage; and this accounts for the degree of favor in which it is still held. But increasing knowledge has enabled the surgeon of the present day to obtain better results by treating fractures of the thigh in the straight position, as before Pott's innovation, and with great diminution both of pain and deformity. This, as we shall see shortly, is accom-

plished by the improvement in our means of effecting extension and counter-extension, due to American ingenuity.

The question of position should be studied in connection with the special treatment of every case of fracture, for it offers other advantages aside from the control of muscular action, which, in fact, may be otherwise prevented from acting injuriously. In fracture of the spine and the pelvis the supine position is a necessity. The fragments of a broken clavicle fall into place more favorably when the patient is lying upon his back; in fact, for double fracture of the clavicle, this position has been found to be the best mode of treatment. The supine position of the trunk, with the arm supported by a Stromeyer's triangular cushion, is claimed by its inventor as the best method of treating a compound fracture of the humerus. When both bones of the leg are broken, dropping of the foot is a frequent cause of faulty union, with deformity by anterior bowing, and it is a symptom not easy to remedy, because the heel is especially intolerant of pressure. Slinging the foot by means of adhesive plaster applied to its sole and sides, the adhesive plaster being then carried over the top of the foot-piece and attached outside, has been practiced at Bellevue Hospital with entire success.

The suspension of a broken limb by a swinging apparatus from a fixed point above is also an effort to gain quiet and security by position. When a limb is thus suspended, the movements of the body necessarily communicated to the proximal fragment are in a measure dissipated by the yielding of the suspending cords, so that there is less danger of derangement at the seat of fracture.

The "anterior splint" of the late Nathan R. Smith, of Baltimore—originally designed for fractures in the lower extremity complicated by a posterior wound—is an ingenious adaptation of the double inclined plane,

combining the advantages derived from suspension. As modified by Professor Hodgen, of St. Louis, it was largely used during our late civil war in the military hospitals.* This apparatus has been still further ingeniously modified so as to combine extension with the mode of suspension. I have seen it in use in the treatment of fractures of the thigh at Guy's Hospital, London.

In fractures of the thigh in children under three years of age, both limbs are flexed at right angles with the pelvis "and hoisted upward to some cradle, hook, or bar above the bed; by these means the weight of the body acts as a constant counter-extending force, and the child can be well looked to for purposes of cleanliness." This plan, which is said to have given excellent results at Guy's, † is adapted to the requirements of an oblique fracture, whereas at this time of life the fracture is usually transverse.

In my experience, Lonsdale's method, which secures a natural position for the limb without such close restraint, has proved efficient for infants in arms. This consists in fitting a strip of sheet-iron—cut a little more than an inch in width, covered with flannel or cotton cloth, and bent as a double inclined plane—to the back of the limb, and keeping it in place by a roller bandage, with the addition of short coaptation-splints of pasteboard at the seat of fracture. The strip of sheet-iron is carried around the heel to the toes, and at its upper extremity it follows the convexity of the buttock as high as the posterior iliac spine. The child can be handled readily, and I have obtained good results from this apparatus. Paget and Callender speak well of the practice followed by them at St. Bartholomew's of treating infantile fractures of the thigh without any dressing whatever, simply placing the limb, after setting, on

* Hamilton's "Military Surgery"; also, "St. Louis Med. and Army Surg. Jour.," No. I, and "Am. Med. Times," May, 1863.

† Bryant "Practice of Surgery," London, 1876.

its outer side, after the manner of Pott, with the hip and knee flexed.*

Permanent extension and counter-extension, required in all cases in which there is persistent shortening of a fractured limb by muscular contraction, is an indication heretofore regarded as involving both difficulty and pain in its accomplishment. It is especially demanded in oblique fractures of the shaft of the femur—"that bone whose fracture," in the language of Pott, "so often lames the patient and disgraces the surgeon." It is, in reality, nothing more than perpetuating or rendering permanent the traction and counter-traction made, under his direction, by the surgeon's assistants at the first examination of the fracture.

The application of an extending force to a limb was formerly effected through the intervention of a silk handkerchief, a leathern gaiter, or a boot of thickly wadded and starched bandage fortified by pasteboard splints. But no devices of this kind prevented severe pain from uneven pressure, and, *if full force was applied for any length of time continuously, eschar and ulceration of the dorsum of the foot and the back of the heel were always likely to take place.*

Counter-extension, when effected by means of a perineal band, even if made of caoutchouc tubing, or never so carefully stuffed and covered, *was always attended with torture* and with danger of eschar whenever the extending force was applied long enough or strongly enough to accomplish its object in the prevention of deformity by shortening; and this serious evil was never remedied by any of the ingenious modifications employed from the time of Boyer's screw until the *introduction of the ordinary adhesive plaster as the medium through which extension is made upon a fractured limb.*

This is the most efficient device for securing safe and adequate permanent extension, say, of a fractured

* "St. Barth. Hosp. Report," 1867.

thigh—a method which the practice of the New York Hospital early demonstrated to be painless as well as efficient. The devices, some of which I have just mentioned, by which the force employed for extension was rendered less intolerable when brought to bear upon a broken limb, are now all of them satisfactorily replaced by the use of the adhesive plaster—a far more ingenious device. Its large surfaces of contact with the skin serve to diffuse the force applied to the latter so uniformly as to prevent pain at any one point. If the cotton cloth upon which the plaster has been spread be stout enough, it never gives way; and if cut lengthwise of the roll, strips of the ordinary plaster *will not stretch.*

The details of the method are very simple. In a fracture of the thigh, for example, stout adhesive plaster is applied in a strip two and a half to three inches wide on both sides of the limb, extending as a loop below the foot. Within the loop a flat piece of wood, wide enough to prevent the strips from making pressure on the malleoli, is inserted. To this a cord is attached, which, passing over a pulley at right angles, has an extending weight at its extremity. A bag of shot or sand would serve as a weight. A loop of caoutchouc tubing, introduced so as to form a part of the extending cord, equalizes the traction. The utility of this device was first pointed out by the late Gurdon Buck, one of the surgeons of the New York Hospital. It has since been used abroad, where it is spoken of as an "accumulator" of power.

Shortly after the adoption of adhesive plaster as the means of applying extension to a limb it was demonstrated that the force, even when carried to the fullest extent, could be successfully counterbalanced by the weight of the patient's body brought in action by the simple device of elevating the foot of the bedstead—first suggested by Dr. Van Ingen, of New York. *Since the entire efficiency of this measure has been verified*

in practice, counter-extension from the perinæum is being less and less employed, and the much-dreaded perineal band is consequently becoming obsolete.

By varying the mechanism just described, an unlimited extending force may be applied without pain to any fracture of a limb.

This mode of effecting extension and counter-extension, which originated in our country and is entirely American in all its details, has taken the place of the methods formerly in use by us, and still employed abroad.

Having noticed the methods employed in applying force for effecting permanent extension, which are mainly illustrated in treating fractures of the thigh, it remains to speak of the *different sources from which the force itself has been derived.* The *weight and pulley* is probably the earliest form of power used for surgical purposes. Aside from the clumsiness involved in its application, when the mechanism employed is sufficiently perfect in construction this source of power leaves little to be desired as to permanence or continuity of action, or as to the facility with which it may be regulated in degree. The *screw* was brought into general use and strongly advocated in fractures of the thigh by Boyer. Although more compact and more easily applied as regards its mechanical adjustment, it is not easy to measure the degree of force exerted by the screw, nor to graduate it accurately; hence this form of mechanical power is with justice associated with the idea of pain not easily tolerated, and with unlooked-for injury to the vitality of the tissues upon which it has been brought to bear.

The elasticity of caoutchouc, at first used in surgical apparatus as a substitute for springs of steel and spiral wire, has been steadily gaining in estimation and in extent of applicability. Syme first called attention to the surgical value of this curious substance. It was first applied in New York as an extending force for

keeping asunder the altered surfaces of diseased joints, and with good results. Shortly afterward it was introduced between the extending force and the limb in the apparatus for fracture of the thigh, at that time in use at the New York Hospital, and subsequently known as Buck's apparatus. Barwell, of London, has also employed caoutchouc as an aid to paralyzed muscles. In 1868 the great advantages of caoutchouc in storing up force—its efficiency, combined with gentleness, continuity in action, and easy management—were demonstrated in the reduction of dislocation, and in the treatment of ankyloses as well as of fractures.*

It is proper to remark here that the amount of power required to tire out the contractility of muscle, and to exercise subsequent mastery over it, is much less than would seem probable from a priori *reasoning —always provided that the power act continuously and through an elastic medium.* Force of a rigid and unyielding quality is found to provoke resistance in the way of spasmodic and irregular manifestations of contractility in the muscular fasciculi.

It is not easy to convey an accurate idea of the *amount* of force employed in any given case without inserting a dynamometer between it and the limb upon which it is acting, as suggested by Nélaton, in reducing luxations by means of the compound pulley. Where we are dealing with a double source of power, as when a weight is acting over a pulley and through an intervening mass of caoutchouc in a state of tension, to estimate the amount of power exerted by each is a difficult problem. *It may be stated in general terms that a dead weight of ten pounds in the treatment of a fractured thigh is usually sufficient.*

In addition to position and permanent extension, other devices are sometimes required to retain unruly fragments in quiet apposition. In certain cases,

* "Des tractions continues," etc., Le Gros and Th. Anger, "Arch. méd.," Paris, Jan., 1868.

through peculiarity in the direction of the fracture or from other cause, a fragment will persistently project and resist efforts at coaptation. Muscular spasm is a frequent cause of this complication, or a sharp projection of bone may have transfixed a portion of muscle or a layer of fascia or even the deeper attachments of the skin, so that it can not be withdrawn by any amount of extension.

After exhausting manipulation with extension under ether, there are other remedial means. Pressure applied upon the bone at a distance from the projecting point by compress and bandage, or a ring or band of caoutchouc, may be tried. Pressure by metallic points imbedded in the fragment, and so sharp and smooth and delicate as to prevent harm to soft parts or bone, has been tried and found effective; but their use has not been generally adopted; whether through prejudice, or because they may have caused suppuration or necrosis, there is not sufficient evidence. Sharp semicircular steel hooks, arranged so as to be approximated at will by a screw, have been used to some extent in treating fracture of the patella; and to this device the same remarks apply. When this complication occurs in a compound fracture there is better ground for using the metallic point, and there is good authority for exsection of a portion of the rebellious fragments, and also for drilling holes through them and wiring the fragments together.

In view of the safety of such a measure, under antiseptic treatment, and the very considerable danger of union with deformity, or absolute failure of union, it would be proper even to cut down upon the fragments in such an emergency in simple fracture and remove the obstacle to apposition.

The very common tendency to deformity by anterior convexity in fractures of the leg may justify subcutaneous section of tendons, especially of the *tendo Achillis*—a measure indorsed by Bryant as an opera-

tion of great value. On the other hand, Ashhurst dissents from this opinion as to the value of tenotomy in this fracture, and "can't conceive of its necessity." † The American device of slinging the foot by means of adhesive plaster I have certainly never known to fail in preventing this deformity.

† *Op. cit.*, 1876, p. 225.

CHAPTER XXIV.

Dislocations.

Dislocation, or *luxation*, is the term employed in surgery to indicate the fact that two bones connected by articulation have had their surfaces thrown out of their natural relations. The bone which is more distant from the trunk of the body is properly spoken of as the dislocated bone.

This lesion is generally the result of violence, and is accompanied by more or less laceration of the ligaments whose office it is to keep the articular surfaces in contact.

But there are exceptionally loose-jointed persons who are able, by voluntary muscular effort, to throw some of their joint-surfaces out of place at their pleasure. When this anatomical peculiarity exists a slight accidental muscular effort of any unusual degree of force may produce dislocation; this is described as a "*spontaneous*" dislocation, to distinguish it from a similar accident caused by external violence, which is designated as *traumatic*.

There are still rarer cases in which, in consequence of imperfect development of the articular structures, the joint-surfaces do not properly correspond and can not preserve their natural relations; these are *congenital dislocations*. They are almost always double, and symmetrical, as seen most frequently in congenital dislocation of the two hip-joints, where the deformity is recognizable at a distance by a certain shortness of stature and a characteristic waddling gait.

Again, the ligaments and surfaces of a joint may be so altered and disorganized by disease that dislocation takes place, in most cases gradually, under the influence of the muscles attached near the joint, especially the flexors. This form of spontaneous dislocation from disease, usually described under the title of *pathological dislocation*, is seen most frequently at the knee-joint, and also in the smaller articulations from chronic rheumatic or gouty arthritis.

A dislocation is usually *complete;* but it may be *partial*, as where the joint surfaces still retain in some degree their normal relations. The latter is called a *subluxation*—a term which sometimes, though incorrectly, is applied to a sprain—a lesion in which the ligaments of a joint are violently wrenched, but without obvious separation of the articular surfaces.

Again, where there is a wound which opens the cavity of a dislocated joint, we have a *compound dislocation.* When there is serious contusion—perhaps surrounding the luxated joint-surfaces with blood from laceration of an artery or a large vein, or lesion of a neighboring nerve-trunk, or where a wound exists in its immediate neighborhood which does not involve the cavity of the joint, or where there is fracture of one of the bones forming the joint—then the dislocation is to be described as *complicated.*

Thus we meet with dislocations which are properly described as *traumatic*, *spontaneous*, *pathological*, and *congenital;* and the first, which is by far the most common, may be *simple*, *compound*, or *complicated.*

Dislocations are also spoken of as *recent*, and *old*—i. e., of long standing; as *unilateral*, and *bilateral*—as in the case of the lower jaw—a central bone, with an articulation at each of its extremities or condyles, which may be luxated on one side only, or on both sides; as *single*, or *double*—i. e., where corresponding articulations, the scapulo-humeral, for example, are both dislocated.

Finally, a dislocation may be *primary*, or *secondary*, as where the head of the humerus, first thrown into the subglenoid position, is subsequently drawn forward by the action of the *pectorales* muscles so as to rest at the root of the coracoid process.

Dislocation is a much rarer surgical injury than fracture. It has been computed that eight fractures occur for every dislocation.

Moreover, the great majority of dislocations take place in the two larger ball-and-socket joints of the body, the shoulder and hip, and by far the larger proportion at the shoulder and in the upper extremity. Malgaigne collected 489 cases of dislocation, of which 62 were located in the lower and 419 in the upper extremity; of the latter, no less than 321 were at the shoulder.

It is evident from these figures that those joints which enjoy the widest range of motion are most liable to dislocation. Disturbance of the cranial sutures, of the teeth from their sockets, or even of the individual vertebræ from each other, are of the rarest occurrence and produced only by extreme violence; while the shoulder-joint, with its shallow socket and loose and capacious capsular ligament, necessary for its very wide range of motion, is luxated more frequently than any other joint of the skeleton.

External violence, and sudden forcible muscular contraction, are the immediate *causes of dislocation.*

Violence applied from without may be brought to bear directly upon a joint, as by a blow or a fall; or indirectly, when forcible impulse is received at a distance from the joint that suffers. An elderly gentleman, walking with his cane under his left arm, stopped one evening under a corner street-lamp to look at his watch; as he stepped off the curb-stone he missed his footing and fell heavily on his right shoulder, driving the head of the humerus into the axilla. The subject of this accident was the late Lieutenant-General Win-

field Scott. But for the watch which he had not yet returned to his pocket, and the cane under the left arm which he had not yet resumed, he might and would have used his hands to break the force of the fall. As it was, the dislocation was produced by *direct violence.* If he had extended his hands to break the fall, a dislocation of the humerus might still have been produced, but it would have been by violence indirectly applied.

A lady, leaping in fright from a carriage in rapid motion, dislocated her ankle, the soft parts at the inside of the joint giving way and the upper surface of the astragalus protruding. This was a case of compound dislocation of the astragalus, and it was produced by violence applied to the joint *indirectly;* thus the weight and momentum of the body was brought to bear upon the ankle-joint through the tibia, and was met and resisted by the ground when the sole of the foot touched it, the force being multiplied by the leverage exercised by the rapidly moving body.

Dislocation is sometimes caused by muscular action alone. The amount of force exercised by this source of power is often greater than we suppose, because the disadvantageous insertion of muscles at the short end of a lever of bone—as of those of the calf of the leg into the os calcis—involves the necessity of providing a largely disproportionate amount of muscular contractility. It is computed that the muscles of the calf, when they raise the body, as in walking, exert a force equal to twelve hundred pounds. Thus the lower jaw is sometimes luxated in the simple act of gaping; and in the convulsive muscular spasms of an epileptic seizure I have known both shoulders to be thrown out of joint.

A boy of fifteen, an epileptic, in whom this accident had happened some years before, was once brought to the clinic of the late Valentine Mott, seeking relief from the liability to recurrence of the luxations which were liable to take place at each return of his fits. In

this case the joint structures were very much relaxed, and the boy's parents had acquired a knack of reducing the dislocations. Ashhurst speaks of an epileptic woman who was in the habit of dislocating her hip in the public streets as a means of exciting sympathy. A case is also related of an angry woman who dislocated the shoulder by raising her arm with unusual force to deal a blow.

The mechanism by which an ordinary traumatic dislocation is accomplished includes, in most cases, both external violence and muscular action, although either alone is competent to produce the result. For purposes of demonstration, we can throw the head of the femur into the foramen ovale, in the dead body, by simple forcible abduction of the limb, the femur acting as a lever, and the Y-ligament that extends from the inferior process of the ilium to the inter-trochanteric line serving as a fulcrum. By extreme abduction, in the dead body, the head of the humerus may be thrown into the axilla. In early life the head of the radius is liable to be dislocated by forcible extension and wrenching of the fore-arm in lifting the body by the upper extremity—as when a nurse drags a child by the hand.

The position of the body or the limb at the moment of suffering violence has great influence in determining the direction assumed by the dislocated bone—i. e., the particular variety of the dislocation. Thus, a young lady, lying on the floor of the cabin of an ocean steamer in a storm, had the uppermost trunk of a pile fall upon her, striking the outside of the hip. I subsequently found the head of the femur upon the dorsum of the ilium and reduced it by manipulation under ether. A man standing with his legs separated and his body bent forward was struck on the back of the pelvis by a bag of grain, by which the head of one of the thigh-bones was forced into the *foramen ovale.*

There are certain *predisposing causes* which tend

to favor dislocation—e. g., the looseness of structure of certain joints enjoying a wide range of motion, as the shoulder; congenital defect in the joint structures, their impairment and alteration by disease, or by accident, as when the brim of the acetabulum has been broken off; finally, atrophy or paralysis of muscles attached around a joint, which in health serve to keep its surfaces in contact, or weakness or wasting of the articular ligaments themselves, or their habitual overstretching, as by acrobats and posturers.

As regards the influence of sex and age, luxations are more common in men than in women, the latter being less exposed to mechanical violence; and also, as shown by statistics, they occur for the most part about the middle period of life—between the ages of thirty-five and sixty-five. In Malgaigne's table, comprising six hundred and forty-three cases of dislocation, there was but one in a child under the age of five. In old age they are equally rare, because the bones break more readily than they undergo dislocation.

It is desirable to get clear ideas as to the anatomical lesions produced in the surrounding soft tissues at the moment a traumatic luxation takes place, and of the changes which are likely to follow from inflammatory action. The amount of laceration of ligaments, or of the muscles and their tendinous attachments, or of blood-vessels and nerves, depends upon the degree of violence which has produced the injury. This is necessarily uncertain, and not easily ascertainable at the time, but it may always be assumed to exist in some degree. Dislocation of the lower jaw is claimed as the only exception to this rule. According to Le Gros Clark, it is mainly by the action of the external pterygoid muscle that this luxation is produced.

Opportunities for dissection after recent dislocations are rather infrequent, and upon these only our exact knowledge is based. A simple vertical rent in the direction of the fibers of the capsule of a ball-and-socket

joint, forming a button-hole opening through which the head of the bone has escaped, is recorded in several instances, and this might constitute a serious obstacle to reduction, in consequence of the difficulty of slipping it back through the same opening.

The changes accompanying old luxations afford more frequent opportunities for study.

In the capsule of the shoulder-joint there is a loose, baggy condition below, near its insertion at the margin of the glenoid fossa, and it is here that laceration occurs most frequently. But for the fact that this weak place in the capsule is guarded and re-enforced on either side by the tendinous insertion of muscles, luxation would be even more liable to occur, especially on extreme abduction of the limb, for in this position the head of the humerus glides off of the shallow glenoid fossa and impinges directly upon this portion of the capsule. Besides laceration of the capsule of the shoulder-joint, the *subscapularis* muscle near its insertion into the lesser tuberosity has been found ruptured; and the greater tuberosity, with the three muscles inserted into it, has been torn away.

Bigelow, in examining a dislocated hip, found "great laceration of the muscles around the joint, rupture of the round ligament, laceration of the inner, outer, and lower parts of the capsule—its anterior portion, constituting the Y-ligament, alone remaining uninjured." In dislocation of the proximal phalanx of the thumb, the two insertions of the short adductor are usually buttoned over its rounded extremity.

Extravasation of blood, which is always present in some degree, leaves evidence of its occurrence in superficial ecchymoses, which do not make their appearance, however, until after some days. In most cases there is little external evidence of bruising about a dislocated joint, although, as we have seen, contusion of the soft parts immediately in contact with the dislocated bone is often extensive.

The stretching of nerves is manifested by tingling pain and numbness along their course and in the parts supplied by them. A large branch of the axillary plexus has been found flattened out against the neck of the humerus; and the circumflex nerve, which winds spirally around this bone, has been stretched and bruised so as to produce paralysis of the deltoid muscle which it supplies.

The changes which follow a dislocation which has been promptly reduced are to be inferred mainly from the occurrence, in exceptional cases, of persistent pain and stiffness, with limited power of motion, or weakness of the joint. This is met with for the most part only in rheumatic and gouty subjects; but its very infrequency illustrates the rapidity and thoroughness with which repair is effected in injuries which are entirely subcutaneous.

The more remote pathological changes which take place when a dislocation has remained unreduced are very constant, and they sometimes present the most curious and fantastic results of nature's efforts to repair the injury and restore the lost function of the part. A familiarity with these possible changes *is of great value in determining the propriety of undertaking reduction in old dislocations.* There is almost constantly an effort to form a new articular surface on which the dislocated bone may regain a chance for motion. This has been most frequently observed in the ball-and-socket joints. In the dissection of the shoulder, in the first of Gibson's two fatal cases, in which the axillary artery was ruptured during the efforts to reduce an old dislocation, he says that the head of the humerus had formed a white, ligamentous, cup-like socket in the subscapularis muscle, and pressing upon the axillary artery had "produced such a degree of inflammation as to give rise to a copious effusion of coagulable lymph, which united the artery completely to the capsule of the joint. The lower part of the capsule was

torn and separated from the neck of the humerus; its upper part remained entire and was very much thickened." In the dissection of the second of Gibson's cases—of about three months' standing when the fatal effort at reduction was undertaken—it is stated that "the head of the bone was found to rest, beneath its original socket, upon a bed of dense ligamentous substance. The capsule was much thickened, and had a rupture in its inferior portion."*

I have seen a well-marked saucer-like cavity formed upon the dorsum of the ilium by absorption and erosion to accommodate the head of a femur which had long been dislocated; and the head itself had also undergone change of shape from absorption, and also, apparently, by friction upon the new socket. The cavity had been deepened by organized lymph deposited around its borders; and its surface was covered by a smooth, shining material resembling cartilage, and the surrounding connective-tissue presented an equally smooth surface, forming a substitute for a capsular ligament. Moreau reports a case of dislocation of the femur into the thyroid foramen, in which this opening was filled with new bone projecting, within, into the pelvis, and externally molded over the head of the femur so as to form a new acetabulum.†

Thus, the dislocated surfaces, when reduction has been long deferred, tend to undergo changes which render their subsequent coaptation difficult or impossible; *so that the propriety of undertaking the reduction of an old dislocation is often a subject of great doubt.*

The *symptoms* of dislocation are: 1. Inability to employ the joint as usual in its natural motions. 2. Change of shape and physiognomy in its contour. 3. Pain in attempting to use the joint, and, in some cases, more or less continuous pain at all times. 4. Discolora-

* "Institutes and Practice of Surgery." Philadelphia, 1841, vol. ii, p. 350, and *seq.*

† "Nouveau dict.," t. xx, p. 768.

tion from ecchymosis, swelling, and other marks of violence.

In considering the symptoms of dislocation, it is principally important to recognize their diagnostic value as distinguishing this particular lesion from others by which the part might be affected. Thus loss of the voluntary power of moving a joint might arise from bruising of the muscles which act upon it, and of the other soft parts surrounding it, rendering an attempt at motion excessively painful. It is to be noticed that a patient usually says, "I can not bend my elbow," when it would be more accurately true to say, "I will not, because it hurts me to do so." We therefore look for other evidences of luxation than simple presence of pain after injury in moving a joint.

The pathognomonic signs of dislocation will be found most surely in *change of shape* in the joint, resulting from an altered natural relation in the articular surfaces to each other. The dislocated bone presents an abnormal prominence, which in most cases may be felt; and its absence from its usual position is manifested by a corresponding abnormal depression.

Thus, in luxation at the shoulder, the head of the humerus is to be recognized in the axilla, while the rounded contour of the joint is replaced by a flattened hollow beneath the acromion, causing a sharp, unnatural projection of this bony process. At the same time the upper arm is elongated and the lower end of the humerus at the elbow stands away stiffly from the side, and *the patient has no power to use the joint even when the effort at motion is not painful.* Here we have a group of symptoms characteristic of dislocation, the most important of which are change of shape in the joint and loss of power to move it voluntarily.

In the most common form of dislocation at the elbow both bones of the fore-arm are thrown backward and upward, usually by indirect violence, the force being applied to the palm when the fore-arm is outstretched.

Here the whole limb is shortened, and the joint fixed in the bent position and deformed in shape by the projection of the olecranon behind the condyles of the humerus.

Pain, I may repeat, is not a very characteristic symptom in dislocation, unless large nerves are subjected to stretching or pressure by the extremity of the dislocated bone, and then this symptom assumes prominence.

I was once consulted for what was supposed to be severe neuralgia of the arm in a stout lady who had fallen heavily upon the shoulder six weeks before. The pain was described as streaming down to the fingers on the slightest effort at motion. On inspection the acromion was seen to project too sharply, and the head of the humerus when slightly rotated could be distinctly felt, although with great pain to the patient, in the axilla, where it was evidently pressing upon the axillary plexus of nerves. The so-called "neuralgia" in this case was effectually cured by reducing the dislocation, which, in consequence of the six weeks which had elapsed, was accomplished only by the aid of the compound pulleys.

Marks of violence on the surface of a dislocated joint are mainly serviceable in showing the direction of the force which has produced the injury, and thus aiding diagnosis.

The symptom of dislocation which most strikingly distinguishes it from fracture is the marked stiffness and rigidity at the seat of injury in the former; fracture, as a rule, showing a false point of motion. If you make traction upon a shortened limb after an injury and succeed in restoring its length, but when the traction is suspended the shortening returns, you have to deal with a fracture.

An exception as to the rule of greater rigidity in dislocation than in fracture is to be noted in the most common, in my experience, of all fractures—that which

occurs at the extreme lower end of the radius, best known as the "*silver fork*" *fracture:* here, almost invariably, tight impaction of the fragments prevents the usual mobility of a fracture. *Hence the exceedingly frequent error of failing to recognize the existence of the fracture when the characteristic deformity is inconsiderable, or of mistaking it for a dislocation of the wrist-joint—the deformity and the rigidity accompanying this lesion, together with the absence of crepitus, are the obvious sources of the mistake—which I do not hesitate to say is one of the most common in surgical practice.* Le Gros Clark says, in regard to the possibility of dislocation of the carpal end of the radius, that "*it is doubtful whether this ever occurs.*"

According to the surgeon last quotod, "laxity of the muscles in the aged renders a dislocated limb far more movable than in the young and robust."

It is important to guard against mistaking the rasping, crackling sensation often communicated to the fingers in dislocation, caused by the presence of blood-clot, or inflammatory exudation, for the true crepitus of fracture. This *false crepitus*, which is less harsh and grating than the sensation of rough bone against bone, is usually spoken of as *albuminous* crepitus.

Dislocation at the shoulder is sometimes, but rarely, complicated by fracture at the neck of the humerus, or of its tuberosities, and, occasionally, of the margin of the glenoid cavity. At the hip, still more rarely, by fracture of the neck of the femur, or of the brim of the acetabulum. At the ankle, dislocation is not unfrequently accompanied by fracture of the malleoli.

Separation of articular epiphyses, caused by extreme force directly applied, is liable to be mistaken for dislocation, as well as for fracture. I have seen this in a boy whose pony trod upon his shoulder after throwing him; and also in a youth of eighteen whose knee was partly crushed, the femoral epiphysis having been rotated so as to present a rounded tumor in

the popliteal space. In these epiphyseal displacements there is usually more or less crepitus, either albuminous or bony, or both, when the parts are carefully examined under ether.

It should be observed as a positive rule in all cases of injury involving an articulation, to examine at the same time the corresponding joint of the opposite side, for the purpose of comparing land-marks, and of detecting any individual peculiarities of formation which may possibly exist.

The immense value of *anæsthesia* in the *diagnosis* of dislocations and their complications can not be overestimated. The abolition of pain and the suspension of muscular contractility afford an indispensable advantage to the surgeon here, as well as in their reduction.

It is obvious that diagnosis should not only make clear the existence of the dislocation, but should determine also its variety, and detect any peculiarities or complications that the case may present. *It is therefore greatly to the advantage of the patient that in all but the simplest cases anæsthesia should be employed—for the double purpose of facilitating diagnosis and reduction as well, not to mention the avoidance of pain.*

Under the head of *prognosis*, in dislocation, it is to be remarked that this surgical accident is liable to be attended by serious consequences—both as regards the subsequent usefulness of the joint itself, and danger to life. As to the latter, the danger is in proportion to the size of the joint and the extent of the injury. Ordinarily, when there is no complication, the reduction of a luxation shortly after its occurrence, by a trained surgeon, is accomplished without any serious danger and with little fear of subsequent disability. But complications rapidly increase the gravity of the case. *There are few more dangerous injuries than a compound dislocation of a large joint, for it involves the question of the excision of an articulation or amputation of a limb, or may be of necessity mortal.* This acci-

dent, which is not infrequent at the ankle-joint, may impose upon the surgeon, at any moment, the duty of deciding this grave question.

In the small articulations, compound dislocation may be possibly recovered from, under judicious treatment, without loss of function in the joint. I have seen the distal phalanx of the middle finger carried backward, at base-ball, so as to expose the whole interior of the joint by a rent across its flexure. The wound was kept immovable for a week in a position of forced flexion, and healed entirely by the first intention —the function of the joint being perfectly preserved, as I verified a year afterward.

The surgical *treatment* of dislocation consists in restoring the displaced articular surfaces to their normal relations as soon as possible after the injury.

When the diagnosis has been made, it is the surgeon's duty, if there is no positive contra-indication, to proceed at once to the operation of reduction. In the great majority of cases, as they occur in practice, the anæsthesia employed for the purpose of diagnosis without pain may be availed of for immediate reduction.

The only serious contra-indication to attempting prompt reduction, besides concurrent injuries causing profound collapse and threatening immediate death, is when the dislocation is of too long standing to warrant a hope of success without too great violence, where anatomical changes may have taken place which would render reduction uncertain or impossible. This is a contingency demanding skill and judgment, and it will be considered fully hereafter.

Dislocations have occupied the attention of surgeons since, and even before, the day of Hippocrates, and in the course of these centuries great ingenuity had been expended in devising means for their successful reduction. The writings of the father of medicine give evidence of a large practical familiarity with the subject. *Their defects consist in a lack of accurate ana-*

tomical knowledge, and in the disposition to rely on brute force for reduction. The old works on surgery, such as those of Scultetus and Heister, which are to be found in our libraries, contain pictures of mechanical contrivances for multiplying force, in the shape of huge and complicated levers and mechanical contrivances.

The latest device of this kind was the ingenious "surgical adjuster," invented by our countryman, Dr. Jarvis, of Connecticut, which still formed part of our apparatus thirty years ago, when I first became a hospital surgeon. Of these mechanical contrivances for multiplying power, the compound pulley alone is still in use, and it is only exceptionally employed.

As an illustration of the old Hippocratic practice, which occurred as late as fifty years ago, it is related by Gibson, of one of his fatal cases already mentioned, that the patient, a heavy man of six feet, before seeking his services had been subjected to suspension from the axilla upon the top of a door, traction being applied to the dislocated arm on one side of the door and counter-balanced by the weight of the body upon the other. But even this did not succeed; and it is not surprising that the violence begot a condition of inflammation by which the axillary artery was glued fast to the dislocated head of the humerus; and this circumstance greatly favored its rupture on the subsequent efforts at reduction.

At the present day it is the mark of the skillful surgeon, in the language of a recent writer,* "not to employ blind force, but to adapt his manipulations to the exigencies of the case, gently eluding the resistance to his efforts, and making the ligaments, muscles, and bones themselves act as efficient mechanical powers under his intelligent guidance." The reduction of luxations in this manner has grown into use since ether and chloroform have been at our command, and since

* Ashhurst.

systematic methods of manipulation have been formulated by Reid, Bigelow, and other surgeons.

The main obstacles to reduction of a recent dislocation are to be found in the active contractile power exerted by the muscles surrounding the joint; and after this, but exceptional in its influence, in the passive intervention of lacerated ligaments, or of bony projections.

The contractile force exerted by the muscles, under the exaggerated excitement provoked by their abnormal bearings, can not be accurately estimated, but it may be safely said to be much greater than usual. Apart from their tonic contractility, their clonic or spasmodic contractions are liable to be inordinately provoked by any attempts to move the dislocated joint. The power liable to be exerted in these spasmodic contractions may be estimated in some degree by the rupture of muscular substance which not unfrequently occurs in the paroxysms of tetanus. All of the "blind force" heretofore mainly relied upon in reducing luxations has been directed to the overcoming of the contractile power of the muscles.

What an immense advantage then the surgeon enjoys at the present day in being able certainly and safely to abolish, for the time, all contractility in the voluntary muscles by anæsthetics. *Their power of annihilating pain is usually regarded as their cardinal quality; but, in the surgery of dislocations, the wonderful quality of suspending the contractile power in the voluntary muscles is of infinitely greater importance.*

The occasional impediment to reduction offered by a torn capsular ligament, when it intervenes between the head of a dislocated bone and its socket—as in a button-hole rent in the capsule of the shoulder or the hip, or where tendons act as ligaments as in dislocation of the proximal phalanx of the thumb—when recognized is to be surmounted by manipulative skill. Such

impediments are the most common causes of failure in recent luxations. On one occasion I succeeded by dividing subcutaneously the tendinous insertions of the short adductor of the thumb, but this is rarely necessary; the rounded extremity of the metacarpal bone in this dislocation can generally be "*unbuttoned*" by judicious manipulation.

Bigelow has demonstrated that the intervention of the tendon of the obturator internus muscle, and of the capsule of the hip-joint between the head of the femur and the acetabulum, as well as the resistance of the front portion of the capsule, which he calls the Y-ligament, are the obstacles to reduction in certain backward dislocations of the femur, particularly of the so-called dislocation into the ischiatic notch, the reduction of which, according to Sir Astley Cooper, is "extremely difficult." In one of his cases, which occurred in the year 1819, this great surgeon describes his efforts at reduction as follows: "The patient was carried into the operating-theatre soon after his admission; and when two pounds of blood had been taken from him, and he had been nauseated by two grains of tartar-emetic, gradually administered, extension was made with the pulleys *in a right line with the body*, i. e., parallel with its axis; the extension was continued at least for an hour and a half, during which time he took two grains more of tartarized antimony, by which he was thoroughly nauseated; *the attempts at reduction, however, did not succeed.* Subsequently, by the aid of the pulleys, extension was made upon the thigh in a flexed position *with success*."*

This case illustrates the harsh means employed in reducing a dislocation sixty years ago, when the obstacle to reduction was supposed to lie mainly in muscular resistance. At the present time it is recognized that the extending force applied to the lower limb in the straight position, i. e., in a direction parallel with the

* "Cooper on Dislocations."

axis of the trunk, is expended upon the very strong anterior portions of the capsule of the hip, called the ilio-femoral, or Y-ligament, and until this powerful band is lacerated there is no effect produced that tends to reduce the luxation. On the other hand, it has been fully proved that a very moderate force applied to the thigh in a position of flexion upon the trunk, by which this ligament is relaxed, is competent, after the muscles have been rendered powerless by ether, to effect reduction.

The amount of blind force that may be uselessly and vainly expended in traction on this ligament is illustrated in a case related by Malgaigne.* "A laborer, thirty-eight years of age, had dislocated his hip backward. The next day Lisfranc, with eight assistants, endeavored to reduce it by straight extension. At the end of an hour their efforts were abandoned, the patient being collapsed. He died on the eleventh day, of suppurative inflammation of the hip-joint, resulting, doubtless, from the operation. At the autopsy the head of the bone was found to lie behind the obturator tendon, and it was easily reduced by flexion."

These cases serve to show that in the treatment of dislocation the principal obstacle to reduction—that offered by muscular contractility—has its effectual remedy in anæsthesia; and that the impediment that occasionally arises from ligament, tendon, or bone, is to be surmounted by simple manœuvres in the way of manipulation, guided by experience and anatomical skill—and aided, of course, by anæsthetics.

Do not fall into the error of supposing that the use of ether or chloroform in reducing a dislocation deprives us of the active aid of any muscles which might be useful in drawing a luxated bone into its place—if "taken by surprise," as Hunter expresses himself, by skillful manœuvres. This idea belongs to the past. It has been proved by clinical experience, since the days

* "Traite des fractures et des luxations," Paris, 1854.

of anæsthesia, to have no foundation in fact. I have heard on several occasions a distinct snap or thud at the moment of reduction in a patient profoundly anæsthetized. It is not easy to explain the mechanism by which muscular contractility is replaced under these circumstances. The simple elasticity of the tissues and the smoothness of the joint surfaces are the most probable factors in producing the result. However explained, it frequently happens that on the slightest handling of the parts, after complete insensibility has been induced, reduction will take place.

In 1847, shortly after the discovery of anæsthetics, a boy of seventeen, who had just had his hip dislocated backward, was brought to the clinic of the late Valentine Mott, when I was his assistant. By his consent I administered chloroform to the patient in the amphitheatre before the class. When entirely insensible I was desired to place the patient in a straight position on his back, so that the features of the dislocation might be demonstrated. Accordingly I drew the boy down by the ankles as he lay upon the couch, and in so doing the dislocated limb suddenly assumed its natural shape, and an audible snap was heard at some little distance, announcing that reduction had taken place. For the moment I was mortified, and disposed to apologize; but we soon realized the discovery of a novel element, and one of inestimable value, in the surgery of dislocations; and I have never since ceased to admire the wonderful results which we are able to accomplish through the ability to abolish muscular contractility by ether and chloroform. In all cases of dislocation I have found them to be an unqualified advantage.

In the *treatment* of recent dislocations I am disposed, therefore, to regard *the muscular relaxation of full anæsthesia* as the first and most important of our remedies.

If asked what is the first thing to be done in a case of recent dislocation, I should answer: Place the

patient under the influence of ether or chloroform, and then proceed to diagnosis and reduction.

In regard to the manipulations to be employed, it is well to rid the mind of the idea that there are any cunning devices to be learned by which success is rendered infallible.

The course to be pursued after the patient is insensible and perfectly relaxed is to find out, in the first place, the exact position of the articular surface of the luxated bone, and then to proceed at once to restore it to its normal relations. With a full and available knowledge of the anatomy of the joint, reduction may often be accomplished by the simplest *direct manipulation* with the fingers—a mere effort at coaptation of the displaced surfaces. This manœuvre is the first thing to be attempted as soon as the diagnosis is clear, in fact, as a part of the diagnosis.

This failing, the next resort is to *indirect* manipulation, employing a dislocated long bone, the dislocated humerus, or femur, as a lever, and aiding the effort and directing it more intelligently by the *direct* application of the fingers to the luxated extremity—endeavoring thus to push or guide it into its proper place.

Thus, in luxation at the shoulder, the humerus is used as a lever, while the fingers upon the head of the bone in the axilla are acting as an intelligent fulcrum and aiding to thrust it in the proper direction.

In that rare complication of luxation of the humerus in which there is a fracture through its neck—when, of course, this bone can not be used as a lever—I have in two instances succeeded without a great deal of trouble in pushing and coaxing the detached head of the humerus from the axilla into the glenoid cavity and placing it in a proper relation to the shaft of the bone, and then in putting up the fracture so as to secure a good union with entire preservation of the function of the part. Before the discovery of anæsthesia such a result as this would have been regarded as an impossi-

bility. In those day the accidents I have described resulted always in permanent disability.

Thus the primary importance of direct manipulation and its indispensable value in the reduction of dislocations may be assumed as demonstrated.

In using the femur as a lever in reducing a backward dislocation at the hip, clinical experience has taught us the value of a certain manœuvre, which is, I believe, universally recognized: first, flexion with adduction; then a gradual sweeping outward of the knee into the abducted position, accompanying this movement by a rocking motion or rotation; finally, bringing the limb down into the straight or fully extended position. My colleague, Professor Markoe, who has recorded the experience of the surgeons of the New York Hospital, has demonstrated clearly the value of this manœuvre; when once witnessed it is readily comprehended.

The *flexed position in reducing all the hip dislocations is now the rule*, because, as Professor Bigelow has shown, it relaxes the powerful ileo-femoral or Y-ligament, and removes all impediment to reduction from this source.

The advantage of "bending the limb at the hip-joint with gentle shaking," in reducing its luxations, was insisted upon in these very words by Hippocrates nearly five hundred years before the Christian era, but only since the use of ether and chloroform in surgery has it become the recognized and intelligible rule.

Thus the treatment of recent dislocations at the present day has, through the advance of knowledge, become a sure and painless proceeding in comparison with the methods formerly employed, in which blind force was the main reliance. It is only in the management of *old dislocations* that the surgeon requires anything more, in the great majority of cases, than the muscular relaxation produced by the full influence of an anæsthetic, and the strength of his own hands.

The difficulty encountered in reducing what is usu-

ally described as an "old dislocation" increases pretty directly in proportion to the length of time since the accident during which the anatomical changes already described may have been taking place. The resistance offered by muscular contractility no longer constitutes the main obstacle to reduction in these old cases. Adhesions and other changes resulting from inflammation now occupy the first place. But inasmuch as these changes—the result, for the most part, of nature's efforts to repair the effects of the injury—may vary considerably, even under apparently similar circumstances, it is difficult to lay down reliable rules as to the length of time which should deter the surgeon from attempting reduction. Thus Sir Astley Cooper fixes the limit at which reduction of a shoulder luxation should be undertaken at three months; but reduction of a dislocated shoulder has been accomplished after a longer period than this; and, on the other hand, judicious efforts at reduction made within this limit have often failed entirely.

In a case recorded by Professor Nathan Smith, of Yale College, both humeri had been dislocated downward by puerperal convulsions in a lady. One was reduced at the end of seven months and a half.*

Fournier has recorded † a dissection of an old hip dislocation in which the acetabulum retained its form and depth and its cartilage at the end of thirteen years after the accident.

Varied periods have been assigned by the highest authorities as the limit at which the reduction of hip dislocation may be properly attempted. Malgaigne gives two years or more as the period at which a dorsal dislocation has been reduced, and only fifteen days for that upon the ischiatic notch. Whereas, according to Bigelow, the latter luxation, by the flexion method, should be reduced within even more facility than the former and after as long an interval.‡

* "Philadelphia Med. Journal." † "Bulletin Soc. Anat.," 1855.

‡ *Op. cit.*, p. 108.

In my own experience, in a sailor who had fallen from aloft at sea, I succeeded, at the New York Hospital, in reducing a backward dislocation of the hip which had existed for six months.

The reasons which should influence a surgeon to decline the attempt to reduce an old dislocation are the following: (1) *the lapse of a long time since the accident;* (2) *the recovery by the patient of a fair use of the limb;* (3) *evidence of new-formation at the seat of the injury looking toward the creation of new articular surfaces;* (4) *the coexistence of serious or mortal disease, especially of atheroma or calcification of the arterial coats.*

The dangers to be feared are laceration or rupture of blood-vessels, especially of an artery of size—as in Gibson's cases—or fracture of bone.

Before employing means for the reduction of an old dislocation the dislocated bone should be subjected, under ether, to passive motion forcibly and faithfully applied, for the purpose of breaking up adhesions, and thus facilitating its replacement.

To measure the extending force which may be exerted by means of the compound pulleys—the mechanical appliance which is most available in reducing an old dislocation—a dynamometer has been devised which indicates accurately in pounds the exact amount of forcible traction at any given moment; and there is also an instrument, devised by Nelaton, by the aid of which sudden relaxation of the extension may be effected, and this manœuvre, combined with simultaneous change of position of the limb, is often successful.

It is well to know that the upper extremity has been torn away, in the dead body, by a force equivalent to about six hundred pounds, but in the living body the shoulder-joint has resisted over a thousand pounds. For this articulation Malgaigne has fixed the limit of justifiable force at five hundred and fifty pounds. This accident has actually occurred in one recorded instance

in attempting the reduction of a dislocation of the shoulder in a woman.

In attempting the reduction of old dislocations, it has happened not unfrequently, as a consequence of the powerful extension and the accompanying efforts to put the bone in place, that, even when these have failed in their object, the condition of the luxated joint has been very materially improved. This is a possible result which should have its influence in favoring a judicious attempt at reduction of an old dislocation; if reduction can not be effected, the subsequent increased mobility of the joint, and the consequent greater usefulness of the limb, may amply repay the effort.

In dealing with what are termed "pathological luxations"—luxations which have taken place in consequence of disease which has altered the shape of the joint-surfaces, and paralyzed the muscles around the joint, or rendered the ligaments insufficient around the joint—their treatment must be in the main preventive and palliative, rather than curative.

The partial luxations which occur in extreme curvature of the spine, as well as in chronic joint affection, are to be treated, as symptoms of these maladies, by mechanical support, excision, or amputation.

Congenital dislocations are very rare, except at the hip, where they are due to imperfect development. The subjects of this deformity are short and thick-set in stature, and have a peculiar duck-like gait, which is readily recognizable. This deformity is generally regarded as beyond remedy; but there are cases on record in which long confinement on the back, in apparatus in which the joints have been retained after reduction, has resulted in cure.*

* "Nouveau dict.," art. "Hanche."

CHAPTER XXV.

Tumors.

A *tumor*, in surgical language, is a local, limited enlargement, taking place at any part of the body, and consisting, in its substance, of *a new outgrowth of tissue which has no physiological purpose in its growth.*

Our knowledge of tumors is based upon what anatomy—especially microscopic histology—and embryology have revealed concerning the materials of which these outgrowths are composed, and the causes of their appearance; and also upon what clinical observation has taught us in regard to their general features, the mode of their production, their progress, and their issue.

This knowledge is not sufficiently accurate or extensive as yet to justify a classification of tumors on either an anatomical or a clinical basis. We do not know enough of their causes to classify them according to their etiology, and are therefore compelled, in describing tumors, to confine ourselves to their external physical characteristics, their progress, and eventual issue, with such light as to their internal minute structure, and its significance, as we can gain from histological scrutiny.

Sooner or later, at the rate of advancing knowledge, the microscope will probably afford ample ground for classification of tumors on an anatomical basis; but for practical surgical diagnosis and treatment at the present time, we certainly require all the additional aid that can be derived from clinical experience.

In regard to the *causes* of tumors little can be said that is not more or less speculative. In fact this department of etiology is confessedly obscure.

By the older surgeons the origin of tumors was ascribed to *inflammation*—that "unknown quantity" which occupied so large a place in pathology before the anatomical school took charge of this branch of science and used the microscope to illustrate the changes in the minute structure of our tissues. Hey, of Leeds, in 1816, described a huge tumor of the thigh—"a strange, distempered mass," as he styled it—under the pathological denomination of "spongoid inflammation." It was what was known later by English surgeons as "fungus hæmatodes," and still nearer our own times as "encephaloid" or "soft" cancer, and at present as a variety of *sarcoma.*

When the anatomical features of inflammation came to be examined and displayed somewhat more clearly, the idea of the inflammatory origin of tumors was lost sight of for a season. Now it is again claiming attention, and many pathologists of note hold the opinion that in *the reversion of tissue to the embryonic condition* (which is now regarded as the main and essential feature of inflammation), and in the tendency to the formation of neoplastic growths by cell-proliferation, by which the inflammatory process is characterized, we shall find the initial stimulus to a large share of the outgrowths we call tumors. In accordance with this view, *a tumor would be properly defined as an exaggerated and purposeless neoplasm.*

The assertion of a recent writer* can not be denied, "that many of the products of inflammation are not only difficult to distinguish from tumors, but are really recognized as true tumors. The criterion of true tumors is considered to be their tendency to permanency, in

* Formad, H. F., M. D., Lecturer on Experimental Pathology, in the University of Pennsylvania, "Archives of Medicine," New York, vol. vi, No. 2, October, 1881.

contra-distinction to inflammatory products, which tend to disappear. But it can be shown that, while true tumors occasionally do disappear, inflammatory products very frequently never disappear."

The idea of the inflammatory origin of tumors has certainly a strong hold upon the popular as well as the professional mind. "Did you ever receive a bruise or hurt at this point?" is a question the surgeon rarely omits when he first examines a tumor. In fact, how often a contusion of a bone in a gouty or syphilitic subject does actually give rise to an exostosis. In like manner oft-repeated irritation of a part seems to bring about epithelial degeneration, as of the pipe in cancer of the lip, or of soot and filth in "chimney-sweeper's cancer."

But if we do admit that the origin of tumors from causes equally capable of producing inflammation is not infrequent, and it certainly seems right that we should, this conclusion by no means explains the origin of a large proportion of the outgrowths we encounter in practice. I once saw an otherwise healthy young girl from the country with upward of twenty exostoses or bony tumors growing from different parts of her skeleton; and a middle-aged man with twice as many fibrous growths each as large as a hickory-nut distributed over the surface of his body. It would be more rational to suspect some central or constitutional cause for such examples of multiple outgrowths. This was certainly true in the case of a gentleman, by whom I was once consulted, who had a score of small, round, black tumors of melanotic cancer scattered over his body.

I may mention, without indorsing it, a recent ingenious suggestion of Cohnheim, of Leipzig, derived from the study of embryology. He holds that true tumors can not originate otherwise than in an anomalous excess of cells in the embryo. In his own language, "there may be produced in an early stage of

embryonal development more cells than are necessary for the construction of a certain part, so that a certain number of cells remain superfluous. Their number may be small, but they possess great proliferating power on account of their embryonal nature." *These surviving superfluous embryonic cells, according to this author, are the source and origin of all subsequent outgrowth in the form of tumors at any time of life.*

This opinion, which at first glance seems purely speculative, has a certain basis of fact. Thus a large and important class of congenital tumors, mainly vascular, and commonly called nævi, takes its origin entirely in intra-uterine life; and the more rare and curious tumors, called dermoid cysts, have very certainly an embryonic source, a reason for their presence in defective embryonic development. But these facts hardly justify Cohnheim's sweeping generalization.

The most obvious ground of distinction between tumors is that which justifies their division, mainly on the basis of clinical observation, into the two great classes of benign and malignant.

We call a tumor *benign* which tends to prolong its existence indefinitely, but does no harm except by its weight and the inconvenience it may cause, its interference with the functions of organs by its bulk, or by its efforts to slough out and rid the organism of its presence.

The histological elements of tumors of this class are more or less closely identical with those of the body in health.

On the other hand, when a tumor involves neighboring parts in its own histological structure, the elements of which manifest a tendency to diverge from the normal type; when it shows an ability to propagate and multiply itself in distant parts of the body; to affect the lymph-glands and the blood; to give rise to ulceration without the power or disposition to slough out and get well; to return after removal, either in its original

site or elsewhere; and to cause cachexia from blood-changes and impoverishment, and finally death—we denominate such a tumor *malignant.*

Another class distinction, only secondary in practical importance to this, is the division of tumors into *cysts* and *solid growths.*

The term "encysted" has been usually applied, in a general way, to such solid tumors as make for themselves, in growing, a distinct investment of ordinary connective-tissue, by means of which their substance might be cleanly separated by dissection or enucleated from adjacent parts. This sort of an investment is properly called a *pseudo-cyst.*

A somewhat similar sac forms around a bullet, or any foreign substance, whose presence has been tolerated by the tissues after being imbedded in them without giving rise to pus-formation. A sac of this latter kind is known as an *adventitious cyst;* it is a simple capsule of newly formed connective-tissue, and is an accidental formation.

The foreign substance under these circumstances seems to excite eliminative inflammation enough to beget cell-proliferation and formation of new tissue around it, but not enough to culminate in pus-formation for its expulsion by abscess. So the newly-formed tissue is organized, and contracts around the intruding mass, apparently for the purpose of preventing its contact with surrounding parts.

A portion of the lock of a gun, which had burst in his hands, was unexpectedly found thus *encysted* in the brain of a young man, who recovered from the accident, as it was supposed, entirely, and died subsequently from another cause.

A bullet lodged in the thorax, at Waterloo, was found safely enveloped by an adventitious cyst in an old soldier who died twenty-five years afterward in the wards of a London hospital.

If the foreign substance be rough or angular, the

adventitious cyst may present a vascular internal surface, ready, on any increased provocation, to take on pus-formation for the purpose of casting it off. I once removed a splinter of yellow pine from the knee of a boy where it had lain for many months almost in contact with the synovial capsule of the joint, causing no inconvenience, but forming a perceptible tumor with a distinct central hardness. The internal surface of the adventitious cyst in which the splinter was lodged presented to the eye the aspect of a healthy mucous membrane; but of course it was simply a surface of granulation-tissue. By keeping the joint immovable for a week, the sac consolidated, by adhesion of its surfaces, and disappeared.

But the word "cyst" is used at the present time with a more technical and clearly defined meaning; it is applied to a tumor that possesses an organized external fibrous membrane or sac, with contents of liquid or soft solid consistence; sometimes even containing other cysts. *The characteristic mark of a true cyst is that it possesses a distinct internal lining of epithelium.*

The *contents* of true cysts present an endless diversity as to material; so that although they are often made use of to designate different varieties of cystic tumors, they can not be taken as a basis for classification.

Cysts occur singly and in groups or nests; and the *contents* of the individual cysts in a cluster of them often *differ markedly* from each other. This is often seen in a mass of ovarian cysts, one of which will contain a pellucid glairy fluid, another a thick material of the appearance and consistence of oatmeal gruel, a third a blood-colored sirupy substance, while a fourth will be found filled with nothing more than simple serum.

When the several cysts composing a group communicate with each other, forming a common cavity,

the aggregate mass forms what is called *a multilocular cyst.*

Cysts belong to the class of benign tumors. Although often associated, through the apparently necessary conditions of textural development, with malignant growths, *they possess in themselves as cysts no quality of malignancy; and their presence is to be regarded as incidental to the locality of the tumor or to its mode of growth.* Thus I once found several cysts in a mammary gland which had been removed for cancer; and in fact its structure was, throughout, infiltrated with a new growth which proved to be undoubtedly cancerous in its nature. Several of the cysts contained masses of the new growth, budding forth apparently from their walls and assuming curious shapes resembling the unfolding branches of a growing plant, not unlike a cauliflower. I satisfied myself that the cysts in this specimen took their origin in obstructed milk-ducts of the diseased gland.

Unlike solid tumors, the *exciting causes* of which are almost always obscure and intangible, the origin of many forms of cystic tumors is quite obvious.

Certain cysts undoubtedly take their origin in traumatism and the inflammatory changes which follow. Thus a repetition of bruises, or a continuous slight irritation, brought to bear upon a portion of connective-tissue, naturally gives rise to an exudation of serous fluid that breaks down its meshes at a central point, and from this point the tissue is thrust away as the fluid gradually collects, and it thus becomes condensed into a cyst-wall. It is in this manner that the cystic tumors called *bursæ* form at points subjected to frequently repeated mechanical pressure, and bursæ already existing are enlarged and converted into cystic tumors. The affection known as *house-maids' knee*, and the *bunions* so common over the great toe-joint, are examples.

It is not likely that blood-clots often give rise to

cysts. In what are called blood-cysts, the contents are always fluid.

An obstruction in the duct or outlet of a secreting follicle or gland is a not uncommon cause of the accumulation of its secretion, as in the tumor that sometimes makes its appearance beneath the tongue, called *ranula.* Here the tumor is curable by re-establishing an outlet for the secretion of the sublingual salivary-gland, for its obstructed and distended duct forms the walls of the cyst. Accordingly we take up a generous fold of the cyst-wall with the forceps, and clip it out with a pair of curved scissors, leaving a hole sufficiently large to prevent it from closing again. The same method of cure is successfully applied to the little cysts, containing a glairy fluid, that form not unfrequently on the inner aspect of the lips. *Tumors formed in this manner are described by Virchow as "cysts by retention."*

The most common examples of them are the *sebaceous cysts*, or *steatomata*, popularly called *wens*, and they are of such frequent occurrence as to deserve particular notice. A case of this kind, in practice, will be most likely to present itself in a woman approaching middle age. These small spherical soft solid tumors, which locate themselves by preference in the scalp, occur about as frequently perhaps in men, but their unsightliness is more likely to prompt the woman to apply earlier for relief. The *steatoma* contains fatty matter, as its name implies (*στεαρ*, suet), and is sometimes spoken of, but incorrectly, as a fatty tumor; but its fatty substance is not adipose tissue: it is simply the solid oily secretion of the sebaceous follicle. According to the usual explanation of its origin, the orifice of a follicle having become accidentally closed or obliterated, the secretion goes on to accumulate within, and necessarily distends its walls, and the occluded sebaceous follicle thus grows to be an encysted tumor.

These diseased sebaceous cysts are better removed

early, by a simple incision through the skin into the tumor and rapid enucleation, tearing the cyst from its bed by a stout pair of forceps, not too sharp at the points, one leg of which has been thrust into the tumor so as to seize its wall, which is sufficiently tough to allow this manœuvre. When small, a dozen of them may be removed, in as many minutes, in this way. Pressure for a short time upon the little wound serves to fix its edges in contact, and no other dressing is usually required. No previous shaving of the scalp is necessary; only the precaution must be observed of not brushing the head for a few days until the wounds have united.

This course is advisable in treating steatoma, because, although no larger at first perhaps than a pea, the tumor may grow to the size of a billiard-ball, and is always liable to be provoked by accidental violence to ulcerate, in which case the tumor discharges its contents lazily and remains indefinitely as a chronic and very offensive ulcer. The cyst, when thus opened, continues to furnish its secretion, which has a rancid odor; it shows no disposition to granulate, and the cyst itself serves as a foreign body to keep the sore open. I have never known a steatoma to get well spontaneously at any stage; and if neglected when small, it may require to be dissected out ultimately by a more severe and painful operation.

I have rarely seen any troublesome consequences follow the removal of steatomatous tumors in the way I have advised; but in an aged or unhealthy person erysipelas might follow, if that disease were prevalent. The operation should not be undertaken, therefore, with out informing the patient of this possible danger.

When a tumor of this kind is situated on the face of a woman, just in front of the ear, over the parotid, for example, where it is not uncommon, it can not be torn out, as I have advised for the scalp, but must be

removed by careful dissection. If the cyst is cut into, and any portion of it left, healing is likely to be delayed, and a sinus may form. To get rid of an operation and the resulting cicatrix, I have frequently drilled a new opening through the skin into the occluded cyst with the sharp end of a probe, and then, squeezing out its contents, *have taught the patient* to repeat the operation as the tumor reappeared. By this treatment I have known a cure to follow.

There is a very large and important family of the class of cystic tumors which are known as serous cysts. They are not so named because they contain serum or serous fluid, for their contents are often opaque and even dark colored, and, in consistence, sirupy or jelly-like. *They get their name from the fact that they are lined within, upon their free or internal surfaces, by epithelium resembling that of serous membranes;* in other words, they approach normal serous sacs like the *tunica vaginalis* of the testis in their histological structure. This distinction is well taken, for there are other varieties of cysts, such as what are called *glandular*, *dermoid*, and *mucous*—the latter being lined by columnar epithelium.

As to the *origin* of serous cysts, we must refer for an explanation to what histology teaches us concerning fully formed connective-tissue, *that its interstices have lymphatics opening upon their walls*, and that *these walls show an epithelial lining, like that of serous membranes;* and that *when distended by fluid they present a strong analogy with the serous cavities.* It is not unlikely, therefore, that fluid oozing into one of these crevices from a lymph-vessel might become the starting-point of a serous cyst, even in the absence of traumatism. A subcutaneous injection of morphine often makes a momentary cyst.

Rokitansky suggests that the serous cysts so often met with in the kidney have their origin in *secreting microscopical cells* which take on a tendency to over-

growth.* *Ovarian cysts, which belong mainly to this family*, are known to take their start from a Graafian vesicle. One of a group of ovarian cysts may take on rapid growth, fill the whole abdominal cavity, and simulate the peritoneal sac, both in appearance and in the character of the fluid secreted. But, at the same time, in this very group other smaller cysts may be found with contents presenting every variety of color and consistence, and one of these might have taken on the same extravagant growth. I have seen the fluid of ovarian dropsy resemble thin gruel, or liquid glue, or pus, or even blood.

The cysts occasionally present in vascular tumors take their origin most probably in secluded blood-vessels, which accounts for their lining of serous epithelium ; and cysts often form in fibrous, fatty, and other benign solid tumors in the same way. The serous cysts developed within the cranium of the insane, where the brain is shrunken, are believed, by Dr. Crichton Browne, to have a similar origin.

Serous cysts are also remarkable for the thinness of their walls. Those delicate little bladders which occasionally form in such great numbers in the chorion, probably in the manner just described, and wrongly called *uterine hydatids*, are typical examples of this family of serous cysts.

Passing from the etiology of serous cysts to the consideration of their *therapeutics*, there is this interesting fact to be stated in connection with the thinness of their walls and their lining of serous epithelium, that they are curable, as a rule, by injection with the tincture of iodine, or some similar irritant, which may safely excite the epithelium to proliferation and bring about consolidation of the resulting neoplasm. This can not be said of any other cysts than those of this family.

Whenever serous cysts are safely accessible, and not too large or too closely connected externally with im-

* Follin, *Op. cit.*, i, p. 161.

portant organs, iodine is a promising remedy. It will interest you to know that Mr. Teale injected a half-pint of the tincture into a cyst of the abdominal cavity with success, and that it has been employed with advantage in dropsy of the knee-joint. The application of this useful remedy to the cure of hydrocele of the testis, which the profession owes to Sir James Ranald Martin, was the first demonstration of its power of safely modifying serous surfaces ; its successful application to the cure of serous cysts happily proves the soundness of the analogy assumed to exist between them. The compound tincture, containing iodide of potassium, is preferable as an injection for the obliteration of serous cysts, as it is not decomposed by dilution with water. My usual plan is to empty the cyst by means of a trocar, and then to inject equal parts of the compound tincture and water ; to allow the injection to remain in the cavity five or ten minutes, and then let it escape through the canula. Its action is precisely the same as in the radical treatment of hydrocele by injection. If the contents of a cyst should prove to be thicker than ordinary serum, I should wash it out thoroughly with an injection of warm water before throwing in the iodine.

The analogy between these cysts and normal serous sacs would seem to warrant us in including the *synovial cysts* or *ganglia* which form upon the sheaths of tendons, as well as hydroceles, in the family of serous cysts ; and such a classification would logically embrace all the serous dropsies. As for the several forms of "hydrocele of the cord," which so often contain spermatozoa, they are already recognized, and properly, as "spermatic cysts" of the serous family, and are curable by the iodine injection.

In the exceptional cases where iodine fails to cure a solitary serous cyst, its extirpation may be undertaken if its walls possess sufficient firmness and are not too closely adherent to important parts. If extirpation

should not seem clearly feasible, a portion of the sac may be excised, and the rest filled in with lint so as to excite suppuration and granulation. Injection of two or three drops of croton-oil has been found to excite active eliminatory inflammation.

In hydrocele of the neck, a seton, consisting of a single thread of ligature silk, is a favorite remedy; and, finally, galvano-cautery with platina wire is said to have been used successfully.

In a lady, whom I saw with Professor Thomas, a fluctuating tumor, situated directly over the femoral opening in the groin, had been very slowly increasing for several years, having reached the size of a large egg. Its situation naturally caused anxiety, as it strongly resembled hernia; but there was no evidence of any communication with the abdominal cavity. It was certainly irreducible. I undertook an exploratory operation, which resulted in a safe removal of a single serous cyst, whole; and the case did perfectly well.

In another case I was consulted by a gentleman of middle age with what seemed to be a fatty tumor situated over the external abdominal ring and extending into the scrotum; it caused him much anxiety, and I advised an exploratory operation. He took other opinions, and was finally subjected to operation for the removal of the tumor by a surgeon of approved skill. The tumor proved to be fatty, and was found to contain, in its interior, a cyst. This was discovered, at the close of the dissection, to enter the inguinal canal by a narrow pedicle, which was finally cut across. Death followed shortly, in collapse from commencing peritonitis.

The sac of a cured hernia has been known to secrete fluid, and become a cystic tumor.

I may mention, as bearing on diagnosis, that in a fatty tumor removed by the late Valentine Mott from the same locality as in the case just related, there was a prolongation of the tumor extending to the perinæum.

Its lobules of fat were so large and so loosely connected as to simulate the sensation of fluctuation so accurately as to suggest a suspicion that a cyst might be present. But none was found, and the case did well.

Many cysts, even of the serous class, are described under the name of *follicular* or *glandular cysts*, because they take their origin in the tissue or ducts of glands or in the minuter follicles. Steatoma, ranula, and the tumors of the lip already mentioned, are examples. Cysts similar to those last named are met with in the glandulæ Nabothi of the neck of the uterus. I have seen them in several instances originating in the vulvo-vaginal glands, and forming tumors in the labia majora, where they obstruct the function of the part by their bulk, and, when bruised, inflame and terminate in abscess. Remember, therefore, in opening an abscess in this locality that you are possibly dealing with a suppurating cyst, and that a sinus may result.

In the *mammary gland*, cysts mostly take their origin in the terminal crypts of the secreting structure, or in an obstructed milk-duct, always taking on the characteristic globular form as they enlarge. At first they contain milk; but after a time this disappears, to be replaced by serum, or material resembling butter or cheese, and of various color and consistence. Such mammary tumors may be composed of a single sac, but they are more often multiple, the smaller sacs feeling like hard nodules. When a large cyst projects beneath the thin skin of the breast, it may show a bluish tint, or it may even be translucent. When this is the case, the nature of the tumor is apparent. As Erichsen says, "nothing is easier than to diagnose a superficially seated cystic tumor—nothing more difficult in some cases than to diagnose one deeply seated at the under surface of the mammary gland." * Explorative puncture by a fine trocar will aid in determining this question. As a rule, removal of the whole breast is the best

* Vol. ii, p. 525.

course. Velpeau, however, gives several cases of successful treatment of single cysts of the mammary gland by injection.

Unfortunately the female breast is so often the seat of cancer, and malignant tumors are so frequently complicated by cysts, that the diagnosis is often obscure.

In a most sad and painful case of cancer, as it afterward turned out to be, I was induced to remove the mamma in a lady of forty-three, mainly because there was a bluish, partially translucent cyst projecting from its surface, and because I could feel no enlarged glands in the axilla.

In another case, of a healthy young married lady of twenty-two, with a very similar looking and feeling tumor which was growing rapidly, I advised its removal promptly, although she was already pregnant, because, under the stimulus of lactation, such tumors are liable to attain a very large size. This lady made a good recovery without any interruption of the uterine functions; and the tumor, which was afterward sent to me, proved to be purely cystic.

In these two illustrative cases the period of life is really the point upon which the diagnosis hinges: the true cystic disease occurring at the age of twenty-two, when cancer of the breast is exceedingly rare; and the cancer at forty-three, a time of life when any other form of growth but cancer is equally so.

There is a rare tumor of the breast known as *galactocele*, or milk-tumor, which may reach a great size. Scarpa describes a case in which the mammary tumor rested on the thighs when the woman was sitting, and contained only pure milk.* Birkett also mentions a case in which he drew off many pints of milk from a similar tumor. This is hardly a true cyst. It is caused by obstruction of the larger excretory ducts, the glands continuing to secrete. If let alone, it would probably

* Boyer, "Œuvres chirurg.," t. vii, p. 217, ed. 1821.

suppurate and burst. The treatment would be to restore the natural outlet.

After the mamma, the testis of the secreting glands is most frequently the seat of cystic growth. As in the mamma, it is most frequently encountered as a complication of cancer. *True benign cystic disease of the body of the testis is rare.* According to Broca * this affection, both in the mamma and the testis, takes its origin, not in obstruction of the larger conduits of the glands, but invariably in occlusion of the common outlet of each group or cluster of the ultimate secreting acini or tubuli. He asserts, in proof of his position, the fact of the myriads of minute cysts often visible in such specimens, far greater in number than the aggregate of all the excretory ducts and their branches, in either gland. Broca asserts, further, that all cysts connected with the excretory ducts, whether they contain spermatozoa or not, take their origin in the remains of the fœtal organ known as the *Wolffian* body. The cysts of the testis which so often complicate fibrous, cartilaginous, and cancerous growths of that gland, are entirely different in their nature from those which take their origin in its secreting structures, and constitute the true cystic disease. Robin, who is the authority for this statement, asserts also that the solid growths just mentioned, often spoken of in a general way as *sarcocele*, have their seat exclusively in the epididymis.*

But it is in the *ductless glands*—in the cells of *the thyroid*, in *the ovary*, and in *the lymphatic glands*—that the formation of cysts is especially interesting to the surgeon, by explaining the nature of the tumors that develop themselves so often in these organs.

In the *thyroid*, cysts take their origin in its primitive cellules, and these grow to a large size and form a

* "Des tumeurs," t. ii, p. 104.

† "Mem. sur l'origine epididymaire des tumeurs dites sarcocele, encephaloide, kystique, du testicule." "Arch. générales de Méd.," Mai, 1856, V[e] serie, t. vii, p. 526.

polycystic tumor, which is *unsymmetrical.* By this feature it is easily distinguished from a true *goitre*, which is a general *hypertrophy of the thyroid body, involving usually the isthmus as well as both lobes.* True goitre is in many cases curable by iodine administered internally; but cystic disease of the thyroid is in no way benefited by this drug, and this is a fact that I hope you will bear in mind, for it is often ignored. I was consulted, quite recently, by a lady from a western city, whose general health was suffering from persistent overdosing with iodine for a cystic tumor involving only one lobe of the thyroid, upon which the treatment had produced no effect, and I have seen quite a number of similar cases. Cystic tumors of the thyroid are innocent in their nature, occurring mostly, if not always, in women, who seek relief in consequence of the deformity. If let alone they rarely attain a large size, and not unfrequently shrink as life advances. I saw one some years ago in an old lady in which the bulk of the tumor had diminished one half, and the walls of the cysts had undergone calcific degeneration, so that the mass felt not unlike a small bag of marbles. She had carried it for many years.

If called upon to undertake the cure of a tumor of this kind, I should not feel warranted in facing the risks attending its extirpation, seeing that the operation would be sought for, not to save life, but mainly to get rid of deformity. I should try a single-thread seton through one of the cysts at a time, or, if proper apparatus were available, galvano-cautery by the platina wire, in the same cautious manner.

Cysts are liable to form in lymphatic glands, and in some cases to cause entire disappearance of the gland structure. A small fluctuating tumor has grown in this manner over the course of the common carotid artery, and has been mistaken for an aneurism.

But the favorite seat of so-called glandular cysts is the *ovary*, where they constitute the majority of the

tumors which develop so frequently from this ductless gland. *Ovarian cysts* doubtless *take their origin, as a rule, as overgrown Graafian vesicles.* In a tumor of this kind described by Rokitansky, this eminent pathologist found an ovum in each and all of its numerous sacs, and none of them as yet developed beyond the size of a French bean.* A group of these growing cysts of the ovary, with vascular ramifications on their surfaces, constitutes a polycystic tumor.†

* "Nouveau dict.," t. xix, p. 740.

† Follin and Duplay, *ut supra*, t. i, p. 168.

CHAPTER XXVI.

Tumors, continued.

THERE is *another natural classification of cysts* which I have not as yet mentioned, viz., into *barren* and *proliferous cysts*. The former includes the examples already described; the latter comprises certain cysts which possess the power of propagating themselves, of generating other smaller cysts, either within their cavities or by growth from their walls externally.

Proliferous cysts vary infinitely in size, and do not communicate with each other except by accident. They are found most frequently, in the female, in the breast, and especially in the ovary. Barren cysts often present chambers of different sizes in their interior; but these *loculi* always communicate with a common cavity; hence such cysts are called *multilocular*. A group of proliferous cysts would be more properly styled "a polycystic tumor." The latter produce *solid growths, in some instances, from the internal surfaces of their walls*, resulting in the formation of what have been called *compound cystic tumors* and *cysto-sarcomata.* In some cases a cyst puts forth from its inner surface a growth similar in structure to the gland substance in the midst of which it is developed, as in certain varieties of *adenoma* of the mammary gland.

Clinically, there is no way in which a growth of this kind can be certainly diagnosticated except where a tumor, already recognized as a simple cyst, has gradu-

ally filled up and become solid. Such tumors may be benign, or they may contain a malignant element; perhaps more frequently the latter. The only remedy applicable to them is the knife.

In connection with growths of this class it is proper to speak of a cystic tumor, *of more frequent occurrence than is generally supposed*, caused by the development within the body of a parasitic animalcule—the *true hydatid*, or *acephalocyst.*

This curious creature breeds from the eggs of a minute species of tape-worm, which are introduced into our bodies with vegetable food. In Iceland, according to von Siebold, every sixth or seventh person is the subject of a hydatid growth. Its frequency in that country is ascribed to the filthy habits of the inhabitants and the number of dogs they keep. Dogs are very subject to this species of tape-worm, which is much smaller than that which infests the human body. It is called *tænia echinococci*, or *tænia nana;* the tape-worm found in man is the *tænia solium.* Myriads of the ova of the tænia echinococci, in Iceland, are passed in the excrement of the dogs, and this, when dried and distributed as dust upon the growing leaves of vegetables used as salads, constitutes a ready vehicle by means of which the ova of the parasite are introduced into the human body. Here they establish themselves (in the way that Steenstrup has demonstrated as "alternate generation") in another form—namely, that of hydatids and echinococci.

An ovum of the tænia echinococci, once fairly lodged in the human body, where, for some unexplained reason, the liver is the seat of lodgment in nineteen cases out of twenty, develops shortly into a little bladder, or coccus. This small bladder possesses a capacity for almost indefinite growth; von Siebold saw one which measured a foot in diameter. It has also the power of producing from its internal surface, by the process of germination or budding, other little bladders, or cysts,

of a somewhat different structure as to their walls, called *germinal cysts*. Each germinal cyst, again, has the power of developing from its internal surface very minute buds, which grow into microscopic animalcules, called *echinococci*. Each *echinococcus*, as it matures, drops off from its internal surface-wall into the clear, pellucid fluid by which the germinal cyst is distended, and each cyst is computed to contain usually about fifteen or twenty of these echinococci.

As this process of proliferation goes on, the original little bladder, which has now grown into "a mother cyst" and attained a large size—perhaps that of a child's head, or even larger—has developed around it externally, out of the connective substance of the organ in which it has established itself, a distinct fibrous cyst of the *adventitious* class.

Thus we have in a so-called hydatid tumor, as developed in the human body, cysts of no less than three distinct species: *first, adventitious*, which is external and contains all the rest; *second, a "mother hydatid cyst,"* which is everywhere in contact with its external adventitious investment; and, *third, an indefinite number of smaller "germinal hydatid cysts,"* which have been produced from the internal surface of the mother cyst. These latter germinal cysts are detached and float freely in the characteristically clear and pellucid liquid by which the mother cyst is distended, just as the animalcules—the echinococci—float freely in the similar clear and pellucid fluid which they themselves contain.

Here, then, you have all the component parts of a hydatid tumor as encountered in the human body.

The substance composing the walls of the "germinal cysts" resembles boiled white of egg in appearance and consistence; it is arranged in layers, or "stratified"; but these cysts often rupture, and their contents mingle with those of the mother cyst. Hence the minute trocar of an aspirator will draw out of a hydatid tumor a clear

fluid like spring water, which leaves crystals of chloride of sodium on evaporating, but contains no albumen; *it will not therefore coagulate by heat or nitric acid.* Under the microscope it will show echinococci; if not the entire animalcule—which dissolves readily when dead—at least its *hooklets*, which are more durable, and present a characteristic and unmistakable appearance.

A hydatid tumor, although most frequently found in the liver, may develop anywhere in the connective tissue of the body, even in the bones.

The tumor presents itself in the shape of a tense globular, painless, fluctuating cyst, which, in its favorite locality, tends to project beneath the false ribs. Its symptoms otherwise are simply those produced by the pressure of its bulk. Developed in the liver, it has caused jaundice, dyspnœa, and dropsy.

In a case I saw some years ago, in a middle-aged man from Peekskill, none of these symptoms were present, but great distress was complained of in the epigastrium, with paroxysms of tensive pain. Some months later I received from his physician a half-gallon jar full of hydatids the size and appearance of turtles' eggs (germinal cysts), which he had passed at stool after a severe attack of abdominal pain, with coincident subsidence of the tumor. The mother cyst had ulcerated by its pressure into the intestinal canal. The man never recovered his health, and died somewhat later, "exhausted by diarrhœa." This case illustrates one of the terminations of a hydatid tumor, and several such have been recorded.

Such tumors are liable to burst into the cavity of the peritonæum and cause death more promptly; although there is a French case in which an hydatid tumor, previously diagnosticated as such, gave way spontaneously, causing a very low grade of peritonitis, from which the patient, a man of thirty, recovered.*

There is a peculiar sensation felt on palpation of

* M. Potain, *Hôpital Necker*, *vide* "Lançet," January 25, 1879.

a hydatid tumor—a sort of vibratory thrill, fremitus, or creaking, which is pathognomonic. Broca asserts that it may be felt in a solitary hydatid vesicle placed separately upon a table. It is not always present. The insertion of a fine trocar into a hydatid tumor, as already indicated, will generally establish the *diagnosis.*

Cases of hydatid tumor have been in many instances cured by the general method of tapping the mother cyst, securing the escape externally of its contents, and the subsequent obliteration of the parent cyst. Where the liver is the seat of the disease, adhesion of the parietal layer of the peritonæum to the surface of the tumor has been heretofore regarded as a condition of safety. This may be assumed to exist when the tumor projects beyond the short ribs ; or if, when the patient is turned upon his left side, it still maintains the same relation to the abdominal wall.

When this point has been determined, a large trocar may be introduced with safety, and a catheter slipped through its cannula and retained—for the double purpose of giving prompt issue to decomposing material, and affording opportunity of injecting and washing out the cavity.

It would seem that the simple withdrawal or chemical alteration of the peculiar fluid of the hydatid cyst is followed by the death of its living contents. It fills up after puncture, but with a coagulable fluid more like ordinary serum. *The main point, if a persistent opening is maintained, is to prevent the retention of putrid material in the sac.* Possibly the opening may be safely enlarged and a free discharge solicited. While the germinal cysts or their *débris* are being expelled, the outer sac will shrink, and finally its obliteration may be attained, either by injections of iodine or by way of suppuration and granulation.

In a case successfully treated by Dr. John Harley,* in which nineteen and a half pints of fluid

* "Med. Chir. Trans.," vol. xlix.

were drawn off by a trocar at the first puncture, a catheter was introduced through the wound, and it was not finally withdrawn from the almost obliterated sac until near the close of the fifth month. Dr. Harley gives synoptical tables, including a hundred cases of hydatid tumors of the liver, in which a cure had been attempted by different operative means. Of *thirty* of these cases in which the tumor was punctured once or oftener, and an external opening kept up, *there were twenty-three cures. He recognizes putrid absorption as a principal source of danger after tapping the sac.* It was formerly recommended to make an eschar over the prominence of the tumor by means of caustic potash, to insure peritoneal adhesion, and then to cut into the tumor through the eschar and discharge its contents. Of the cases treated in this way more than half died.

Simple *electrolysis*, proposed by Althaus, of London, has been tried in eight cases with success.* The current seems to have acted upon the fluid in the cyst in such a manner as to destroy the life of the parasite, and the tumor in each case slowly and gradually disappeared. *This would seem at present to be the most promising plan of treatment for a hydatid tumor.*

Hydatids of the liver are probably more common than is generally supposed. They are not infrequently the cause of jaundice and other symptoms ascribed to the impaction of gall-stones. This at least is the impression I have received, mainly from the researches of the late Dr. Murchison, of London. The parasite seems to establish itself in the gall-passages by preference.

In addition to the symptoms already mentioned by which its presence may be recognized, *it is well to keep an eye to the urinary and fecal discharges. Davaine has recently reported cases in which he was able to make diagnoses where no tumor was perceptible, by de-*

* "Med. Chir. Trans.," vol. liv.

tecting echinococci and fragments of cysts in the excreta.

A liver was once exhibited at the Pathological Society of this city which contained a hydatid cyst as large as a small orange. It was discovered in the examination of a fatal surgical case at the New York Hospital, and its presence had not been suspected. The sac had a semi-transparent, pearly tint upon its inner surface, and consisting, as it did, of the mother hydatid and the exterior adventitious cyst, it was about a line in thickness.

It is important for you to know that there are very loose ideas prevalent concerning hydatids. In looking over American journals for cases, almost all reported under this title I found to be *serous cysts of the chorion*, generally spoken of as "placental" or "uterine hydatids"; and synovial bursæ, with fringed processes containing little serous cysts; with here and there a case of "hydrocele of the neck." Now I know of no reported case of true hydatid in the uterus, nor in either of the other localities mentioned. Sir Astley Cooper, in his great work on "Diseases of the Breast," describes solitary serous cysts under the name of hydatids (Paget); and it is only since the labors of von Siebold, Küchenmeister, and Davaine have made us familiar with the nature and habits of these parasites that accurate distinction in language has become possible.

An outgrowth, apparently of bone, may be caused by the development and growth of a cyst within the osseous substance, or in one of its natural cavities, as in the cranium, or antrum of Highmore. The bony tissue may be absorbed within, under the pressure of an enlarging cyst, and it may increase in thickness, at the same time, externally. Such cysts are met with most frequently in the jaw-bones, and they are usually designated as *bone-cysts*. The antrum of the superior maxilla is a favorite locality for them; but, obviously,

such a growth is rarely detected until after it has begun to cause an external prominence.

In making a section once of an antrum for anatomical purposes, I discovered that this cavity contained a globular cyst, the size of a small cherry, attached to its lining membrane. It had a dense fibrous wall and glairy contents, and probably took its origin in an obstructed mucous follicle.

As a cyst of the antrum grows, it distends the cavity, producing absorption of its bony walls and causing great deformity. At a certain stage of its growth the bony envelope of a cyst may become so much thinned as to yield to pressure of the fingers with a sensation as of the giving way of dry parchment.

Perhaps the greater proportion of cystic tumors of the jaws, especially of the inferior maxilla, take their origin in the sacs of young teeth, forming what Paget has described as "dentigerous cysts"—in which there is a perversion of normal development in a tooth-sac resulting in an indefinitely growing cystic tumor. I have seen a number of these tumors, all seated in the lateral aspect of the body of the lower jaw, and presenting a characteristic fusiform shape; most of them had been regarded as growths of a suspicious nature, and treated by removal of half of the jaw-bone by disarticulation. I saw and examined quite a number of these dentigerous cysts of the jaw in the anatomical collection of the late Valentine Mott, which was destroyed by fire in 1865. It was my privilege, many years ago, to examine very closely all the specimens in this collection, with the object of preparing a revised catalogue. This surgeon had been among the first to disarticulate the lower jaw, and several of his permanently successful cases, supposed at the time of removal to be "osteo-sarcoma"—and so labeled—were found to be simple dentigerous cysts. The real nature of these cysts was first pointed out by Forget, in 1847.

We know now that these tumors of the jaw are

entirely benign, and, if recognized early, are curable, like other cysts in bone, by cutting away freely a large portion of the bony wall, removing as much as possible of the cyst with its contents, and soliciting granulation from the bony surface—a mode of proceeding that will rarely fail to effect a cure. Nélaton employed a curved rasp upon the surface of a cavity in the upper jaw that he could not otherwise reach, and with excellent result. The cutting burr worked by machinery, as now employed in dentistry, might be of value for a similar purpose. It is important that the opening of the newly made cavity should be *dependent;* or, if not, that it should be frequently and thoroughly syringed out.

I have lately seen, with my colleague, Professor Sayre, a lady from the South with a large globular and distinctly fluctuating tumor developed over the left canine fossa and bulging into the mouth beneath the upper lip. The mucous membrane over the projecting tumor was livid and congested, and the growth had been regarded as malignant. Externally, its physiognomy was suggestive of a distended antrum. Exploration through the socket of a decayed first molar proved, however, that this cavity was in a normal condition. As the teeth were all present, or "accounted for," there was no ground of suspicion that it could be a dentigerous cyst. The aspirator, introduced above the canine tooth, withdrew several drachms of a glairy, structureless fluid—thus confirming the diagnosis of simple cyst—which in this locality is rare. A large and free depending opening, maintained by systematic syringing, was followed by contraction, and prospect of satisfactory cure.

We have next to examine a class of cysts of a very curious character, known as *dermoid cysts.* Their contents are made up of sebaceous material of the appearance and consistence of butter, or of a greasy gruel. With this material are mingled hairs, mostly short and colorless, but *sometimes long, and growing from folli-*

cles in the inner surface of the cyst-wall. In addition to the hairs, but more rarely encountered, there are found imperfectly developed teeth and irregular masses of bone.

These cysts are always congenital; they are often at first hardly noticeable, and quiescent, taking on a tendency to grow later, not infrequently at the period of puberty. One of their favorite seats is in the testes and the ovaries; but they occur elsewhere.

Velpeau got great credit for a brilliant diagnosis in a case of this kind in a man of thirty, who entered La Charité Hospital, in Paris, when I was a dresser there, in 1839. This man had a tumor of the testicle which had existed since his birth, but had begun shortly before to enlarge in consequence of an injury, and was now suppurating. From the orifice of a sinus on the surface of the scrotum, Velpeau discovered a hair protruding, which he drew out with the forceps. It was several inches in length, and differed in color from the hair growing on other parts of the patient's body. On this circumstance and the congenital history of the tumor, Velpeau based his diagnosis, and, after removal, it was found to contain not only hair, but teeth and bone. These strange tumors were formerly supposed to be the encysted remains of an undeveloped twin fœtus included in the organism of the developed twin, and they were described as a congenital deformity resulting from so-called "fetal inclusion."

The anatomical similarity between the structure of the walls of these cysts and that of the skin, which justifies the name of dermoid now given to them, was first pointed out by Kohlrausch.* Their contents, you will observe, are the usual productions of a cutaneous surface furnished with hair-bulbs and sebaceous follicles. The teeth and bone belong, like the true skin, to the connective-tissue group. This brings us to the explanation of the cause of dermoid cysts, and this

* Müller's "Archiv," 1843, p. 365.

knowledge is derived from the science of embryology.

The embryo is developed from three formative layers, each producing a certain series of organs. These are called *blastodermic membranes*. The most external of these, known as the *epiblast*, which comprises the tegumentary layer, develops from each lateral region of the embryo, and ultimately unites in the median line. An arrest of development results in failure of union, and explains the occurrence of certain not uncommon deformities which surgery is called upon to remedy, such as *hare-lip*, *spina bifida*, *exstrophy of the bladder*, *epispadias*, *and hypospadias*. Now, irregular, abnormal, or redundant development gives rise to occasional turning in of the advancing margin of the tegumentary blastodermic layer, so that germinating surfaces are included when the lateral halves of the embryo grow together. These fragmentary patches of formative membrane become the sources of abnormal development beneath the surface, and in this manner misplaced or included portions of the tegumentary layer of the embryo at a later period form *dermoid cysts*.

The possible abnormal inclusion of blastodermic germs elsewhere, and under other circumstances, during fetal development, has been assumed by Cohnheim as the source of origin, also, of solid tumors.

As early as 1857 the distinctive characteristics of dermoid cysts were pointed out and admirably illustrated by Lebert, in his great work on pathological anatomy; but our knowledge of their blastodermic origin is more recent.

With this knowledge of the nature and sources of dermoid cysts you will recognize that cysts of the scalp, even although apparently steatomatous, when occurring in early life, and possibly congenital, should be approached with great caution.

Dermoid cysts occur, in fact, most frequently on

the head, especially in the neighborhood of the supra-orbital ridges; they are also developed beneath the chin, in the median line, extending deeply between the muscles of the tongue; and also in the pelvis, as well as in the scrotum and in the ovaries. When situated about the head, *the bone beneath the cyst is often wanting*, and the cyst may even communicate with the dura mater within. Heurtaux reports a case of dermoid cyst, the size of a large orange, situated over the anterior fontanelle, in a man of thirty, in which he found the bone wanting in a spot two thirds of an inch in diameter. The tumor, he says, was carefully dissected from the dura mater and a flap of scalp applied to its surface, with a successful result.*

The best treatment for cysts of this variety, as a rule, is removal by dissection where practicable; but it must be undertaken with circumspection. Treatment by caustics, iodine, and irritating injections may possibly succeed, but my experience has not been satisfactory. An unsuccessful attempt at removal might be followed by renewed growth. This was the result in an interesting case observed by that excellent surgeon, the late Mason Warren, of Boston, in a girl of fourteen, whose history he traced for many years afterward, declining on several occasions to sanction any further interference.

In a young man of nineteen, a fluctuating tumor as large as an egg, situated immediately below and in contact with the symphysis of the chin, gave issue, when tapped, to a greasy, grumous substance of a gruely consistence, and I was unable to effect the entire obliteration of the cyst subsequently by iodine and other irritating injections. When this patient last visited my clinic he had still a small fistulous orifice, yielding a somewhat offensive discharge.

In another similar case, also apparently congenital, in a gentleman of thirty-two, which was growing and

* "Nouv. Dict.," t. xix, p. 755.

becoming unsightly from its bulk, I had determined to attempt the removal of the cyst, which extended deeply between the muscles at the base of the tongue, when one day it discharged itself spontaneously through a minute ulceration in the floor of the mouth, opposite to the last molar tooth, and relieved itself so entirely that the patient was satisfied without further interference. This, I learn, has since occurred, at intervals, several times, the tumor having shrunk greatly. The contents of this cyst were liquid and greasy.

I was once consulted by a physician for a painless tumor of the testes of his son, five years old, which had first attracted attention three years before. At this time he had consulted the late Valentine Mott, who expressed a fear that it might be the commencement of malignant disease. During the three years which had elapsed, the tumor had increased somewhat in bulk, keeping pace, seemingly, with the growth of the child. There was nothing sufficiently positive in its irregular and slightly nodular configuration and varying consistence at different points to warrant a positive diagnosis. It certainly had not pursued the invariably rapid course of a malignant growth of the testes at this period of life. On the whole, I decided to remove it in the winter of 1866–'67. When the tumor was laid open, we found in a cyst, together with other materials, several teeth and an irregular piece of bone representing an alveolar process. The boy made a good recovery, and has remained well.

Analogous entirely to *dermoid cysts* are similar cystic tumors with walls lined by mucous membrane instead of skin, and to these the title of *mucous cysts* has been applied. These tumors, which are also congenital, are still more rare than dermoid cysts. Their contents are various, and their walls have been found in several instances covered with epithelium provided with vibratile cilia.*

* "Nouv. Dict.," t. xix, p. 736.

Certain cysts developed in front of the larynx and trachea, in the median line, belong to this class; and there is a case recorded in which a mucous cyst, situated in the front of the leg, over the tibia, had been removed and subjected to examination.*

For these cysts careful extirpation by the knife, when feasible, seems to be the only certain treatment. If not entirely obliterated, a sinus will remain. Neither seton nor iodine injection can be certainly trusted to cure them. Nevertheless, my friend, Professor Sands, tells me of a case cured by iodine injection.

Most standard authors are unsatisfactory in their description of these cysts, but are unanimous in regarding them as refractory under any treatment save entire extirpation.

In a female child of thirteen, from the West, who had a fistula in the median line of the neck just above the notch of the thyroid cartilage following a congenital tumor which had been opened, I found that the fistula led into a distinct cavity of some size. The walls of this cavity I destroyed as thoroughly as possible by removal; and subsequently, by thorough applications of caustic, I succeeded in healing the fistula. Twelve years afterward I had a visit from the patient, now a married lady, complaining that the fistula had recently reopened; but the orifice was very minute, and it soon closed again under the influence of improving health.

The late Dr. John Watson reports several cases in which fistulæ in this locality were cured by caustic injections. He employed a solution of corrosive sublimate with muriate of ammonia.

In summing up the means at our command for curing cysts in their various forms, I may remark that a cyst will sometimes, but very rarely, disappear spontaneously; that it is but little less rare for a cyst to get well by absorption of its contents under the use of pressure, either alone or in conjunction with the

* Heurtaux, *ut supra.*

external application of iodine or blisters; and that the previous use of these remedies tends to render subsequent removal a less simple proceeding.

The cysts which suppurate readily and get well most promptly by granulation and contraction belong to the adventitious class, and have no lining of epithelium.

Among the more efficient remedies for true cysts are: 1. *Crushing*—as of ganglia and of some blood-cysts, the diffused contents subsequently undergoing absorption. 2. *Injection of iodine*—applicable to thin-walled serous cysts which can collapse and adhere within, as in hydrocele, which, clinically, may be regarded as a cyst of this class; electrolysis, to extinguish parasitic life, as in true hydatid tumors. 3. *Incision*, or *partial excision*—with or without the use of caustic or cautery—to destroy a secreting surface of epithelium; and dressing-in with lint, to promote suppuration and granulation. This method is applicable to cysts with thicker walls, as to certain hydroceles not amenable to injection, cysts of bone, bursæ, cysts of the vulva, of the lips, and to cannula. 4. *Entire removal*, either by avulsion or by careful dissection without opening them; applicable to cysts with dense walls, such as sebaceous and glandular cysts, dermoid cysts, etc.; or, finally, removal in bulk, as of a testicle, mamma, or a polycystic ovarian tumor.

Solid tumors, which we shall next consider, are more amenable than cysts to classification in accordance with their anatomical elements; and the names by which they are now most generally known, derived, for the most part, from their textural structure, indicate in a great degree their pathological character, and are at the present time very generally adopted for clinical use.

A recent classification, which embraces the latest German advances in pathology, is that of Lücke, Professor of Surgery at Berne, the co-editor with Billroth of the "German Surgery" now in course of publication. Its author is a supporter of the *blastodermic*

theory, as it is called, which attaches so much importance to the impulse derived from the forces which preside over embryonic development in determining the nature and causes of the growth of tumors, as well as the particular tissues in which they take their origin. This theory, which seems rational and plausible, is manifestly gaining favor. I reproduce Lücke's classification as a guide, without permanently adopting it, because it is simple and convenient as well as novel. He divides solid tumors into (1) "*new growths in the type of connective tissue*," including under this head *fibroma*, *lipoma*, *chondroma*, and *osteoma;* and in "*the type of embryonic connective tissue*" he includes *myxoma* and *sarcoma;* (2) "*new growths in the type of epithelial tissue*," among which he ranges *carcinoma*, *epithelioma*, and *melanoma;* (3) "*new growths in the type of more highly developed tissues*," including *papilloma*, *angioma*, *neuroma*, and *adenoma*.

The most novel feature in this classification is, that carcinoma is assumed to be of epithelial origin as well as epithelioma. The German school of Thiersch and Waldeyer, to which Lücke gives his adhesion, has abandoned the doctrine of Virchow, that cancer takes its origin in connective-tissue cells. Of this, however, we shall have occasion to speak hereafter.

The term *fibroma* is applied to growths in which the white fibrous element of connective tissue is the principal constituent. These growths present themselves in two distinct forms: *soft* and *hard fibromata*.

The softer variety of fibrous tumor occurs, almost always, as an outgrowth from the true skin; more rarely from the mucous membrane near the outlet of a great canal, as in the nostrils, in the form of polypus. It is sometimes congenital. Although generally single, soft fibromata may be multiple.

As to its mode of appearance and growth, a little soft nodule forms in the substance of the true skin, and, apparently, in the effort to extrude itself—*which*

seems to be a characteristic feature under all circumstances of the fibroma—pushes the more external portion of the skin before it, so as to present itself as a surface tumor, which tends gradually to become pedunculated, and finally even pendulous. In this form it is covered with a very delicate layer of skin, or mucous membrane, invested with cuticle or epithelium.

More rarely, the tumor at first grows inwardly, so as to develop in the connective tissue beneath the skin, and subsequently pushes the whole thickness of the latter outward, so as to make an investment of it; after this it may increase in size indefinitely, and also become pendulous.

The softer fibromata, when laid open, resemble connective substance within; they show in their interior structure numerous minute areolæ, or meshes, which contain an albuminous fluid. They are also often œdematous, from obstruction in their circulation, a result of their characteristic tendency to pedunculation. They constitute the large class of tumors—called, popularly, *wens*—that grow from the surface of the body; and some of them have attained a large size and great weight. The softer nasal and uterine polypi belong to this class. So also do certain *congenital* growths of the skin which seem to locate themselves by preference on one side of the face, but which are also met with in other parts of the body.

Some authorities classify *elephantiasis*, as it occurs in the leg and scrotum, as a diffuse variety of the soft fibroma. In a case of elephantiasis involving the leg of a young woman, in the adjoining hospital, which I had an opportunity of carefully studying after death, from an intercurrent malady, I found nothing to account for the huge enlargement beyond simple hypertrophy of the skin and connective tissue of the limb.

The best *treatment* for fibrous tumors of this class is removal by the knife, or ligature—unless the extent to which the skin may be involved, as is sometimes the

case in the congenital variety, should render an operation too formidable. Even here the removal of a tumor involving a large extent of skin may be undertaken by instalments, or flaps of adjacent sound skin may be used to diminish the gap, or skin-grafting may be employed.

Where soft, fibrous polypi grow from mucous surfaces, avulsion, or twisting off by forceps, may be substituted.

The *harder fibromata*, which resemble more in their consistence the denser white fibrous tissue of tendon or ligament, may take their origin elsewhere than from the skin ; they arise not infrequently from the periosteum.

The fibers of which these tumors consist generally show a nucleus under the action of acetic acid, proving their connective-tissue origin, and they tend to arrange themselves concentrically in minute groups, each group having a blood-vessel in its center. It is at these points that the cavities containing fluid, so often seen on section of hard fibromata, take their origin. *There is also a tendency to felting of the fibers of which these tumors are composed, just as we see in the normal structure of the true skin; and this obvious imitation of the dermal structure explains the almost constant presence in the harder fibrous tumors of smooth or unstriped muscular fibers.*

The hard fibroma occurs most frequently on the surface of the body, in or immediately beneath the skin. While rarely attaining a very large size, it presents itself occasionally in a multiple form. I have seen as many as thirty of them, varying in size from a cherry to an English walnut, scattered promiscuously over the surface of the body.

A favorite locality of the hard fibroma is at the base of the skull, whence it is liable to encroach upon and penetrate the nasal cavities from behind, forming a polypoid growth of fibrous consistence. Still more frequently the hard fibroma selects the walls of the

uterus as its seat of development, and *here it manifests the same tendency to extrude or enucleate itself from its original seat that I have already noticed*, seeking, apparently, more space for growth. Thus we encounter fibrous tumors of the uterus literally sprouting into the abdominal cavity and also into the cavity of the uterus, whence, in some instances, the tumor is again extruded into the vagina.

Fibrous tumors, especially in the uterus, and in its answering part in the male, the prostate, *are blended in their minute structure with so large a proportion of smooth muscular fiber in many cases as to justify the designation of "fibro-muscular" or "fibroid" growths.* Virchow has given the name "myoma" to these compound tumors.

I once saw, in consultation in the country, a bedridden woman who had been long supposed to be laboring under a mortal disease. She had constant pelvic pains and gastric distress, and profuse leucorrhœal discharge. I found the vagina occupied by an enormous fibrous tumor, which had evidently been extruded by the uterus, and was still attached by a pedicle just within its neck. The size and shape of the tumor were not far from those of a bullock's heart. I managed subsequently, by the aid of Gooch's ligature-carrier, with some difficulty, to get a ligature around the uterine attachment of the tumor, and, when this had cut through, I extracted the detached mass from the vagina by means of obstetrical forceps. When laid open, this mass proved to be a purely benign, hard, fibrous tumor, with a certain proportion of unstriped muscular fibers in its structure; and the section showed numerous cavities scattered throughout its substance, varying in size from a pea to a nutmeg, and containing a sticky, albuminous fluid.

In another middle-aged woman, to whom I was called to relieve retention of urine, I found a very similar hard mass actually protruding from the *ostium vaginæ*,

which was so thoroughly distended by it as to occlude the urethra. I cut away on the spot a wedge-shaped portion of this tumor in order to relieve the bladder, and the structure of the excised portion was identical with that just described.

Another fibrous tumor—developed in the ovary and constituting a large movable mass, to remove which I was obliged to employ the large abdominal section—showed the same internal structure, with cavities containing fluid, and projecting from its surface was a translucent cyst, the size of a turkey-egg. This young woman, who was twenty-five years of age, recovered entirely, and subsequently married.

In another case of a woman, who died in my wards in the adjoining hospital, a hard, globular, fibroid tumor six inches in diameter occupied the peritoneal cavity. It was remarkable for an extreme degree of mobility. I was deterred from removing it by the prevalence of erysipelas and puerperal fever. The patient, without apparent cause, was suddenly attacked one day with symptoms of acute entero-peritonitis, and died. The tumor, which resembled in structure those already described, was attached by a very long pedicle, consisting of peritonæum and blood-vessels, to one of the broad ligaments of the uterus, and this pedicle had become so tightly twisted upon itself as to interrupt the circulation in the fibroid mass, and thus the fatal inflammation was excited.

There is a rare and peculiar variety of hard fibroma that occurs in the negro, of which I saw an example many years ago at the clinic of the late Valentine Mott, who subsequently removed it. This tumor, which was densely fibrous, was seated over the parotid; it was cylindrical in shape and about three inches in length, and resembled a roll of sausage.

The elder Warren, of Boston, describes and pictures an almost precisely similar case in his work "On Tumors." He names the disease "eiloides" (from ειλεω,

to roll), from its curious shape. I have not seen this curious variety of fibroma described elsewhere.

There is a variety of fibroma in which the fibrous stroma is singularly slender and delicate—rarefied, as it were, into a skeleton—so as to multiply greatly the cavities in its interior, to such an extent, in fact, that their aggregate contents form the main bulk of the tumor. These contents resemble, in translucency and consistence, the albumen of a raw egg, and contain mucus; and from this peculiar feature the tumor has received the name of "*myxoma*" (from μυξα, mucus). Myxomata are essentially fibrous tumors, but, nevertheless, soft in their feel externally; the tendency to form cavities in their structure during growth has evidently predominated over the tendency to form fibers. The mucous contents of the cavities show no formed elements. *There are cases in which cells are found in the cavities of such a tumor associated with the mucoid material; such a growth would be properly called a myxo-sarcoma.*

Fibromata are thus seen to assume various histological aspects without losing a right to their title; and, clinically, they show the same variety without losing their benign character.

When neglected, a fibrous tumor may reach a very large size; it may cause ulceration of its integumental investment; it may slough entirely or partly, putting on a resemblance to cancer.

In the varieties of tumor known as *fibro-plastic*, or *recurrent fibroid*, the presence, in large proportion, of cellular elements places them under the title of sarcomata rather than of fibromata.

A *lipoma*, or fatty tumor, is the most common and the most certainly benign of all tumors. It consists of lobules of fat, all larger than natural and varying in size, enveloped in and held together by connective tissue, which is in some cases loose and delicate and in others more dense, according to the position of the

growth. Thus a lipoma is simply a circumscribed unnatural outgrowth of common adipose tissue.

A woman of middle age may present herself with a lump on her back, or perhaps on her shoulder, which she tells you has been growing for four or five years, but has only of late become so large as to show externally. On feeling it, you recognize a soft, solid, irregularly but smoothly lobulated mass, rounded and flattened in shape, more or less movable according to its size, with the skin adherent to it, but also slightly movable upon it except at certain points, and readily thrown into dimples at these points when the mass is compressed at its sides by the traction of connective-tissue bands attached to its deep surface, the whole mass being evidently imbedded in the connective tissue between the skin and the deep or muscular fascia.

The patient will give you no account of pain of any kind in the tumor, hardly even when forcibly compressed by her dress. When you grasp it with the hand, there will be no complaint, and the tumor will give you the sensation of being made up of lobules that glide upon each other. The gliding upon each other of the larger lobules in a fatty tumor may simulate the sensation of fluid so closely as to raise a suspicion that a collection of liquid or a cyst is really present; which, in fact, is sometimes the case, although rarely.

The proper treatment for a growing fatty tumor is to remove it, simply because an operation will become more redoubtable as the tumor increases in size, and its removal later and under less favorable conditions might become imperative. The cases in which a fatty tumor stops growing are rare, and those in which a growth of this kind disappears spontaneously exceedingly so. Their removal is most readily effected by a free division of the skin and subsequent enucleation of the tumor; this is accomplished mainly by tearing through the bands of the enveloping capsule of connective tissue by means of the fingers, aided, possibly, by the handle of

the scalpel and the occasional division of a denser band by its cutting edge.

After tying the vessels, if any, the wound is to be closed accurately except at a depending point, where a drainage-tube should be inserted. Over the flaps and the line of sutures place a liberal compress of cotton-wool, and apply the bandage carefully and snugly enough to insure accurate contact of the raw surfaces. *If the dressing is skillfully managed, prompt union, even of fatty surfaces, may be almost certainly obtained.*

There is a variety of fatty overgrowth affecting the shoulders and buttocks by preference, in some cases symmetrically, in which the lobules are smaller and the line of separation between the tumor proper and the surrounding adipose tissue is wanting. This affection constitutes rather a deformity in the shape of *local obesity* than a tumor, and occurs very rarely except in women.

In a young woman affected in this manner in a marked degree, who entered the New York Hospital for the purpose of getting rid of a very large tumor, evidently fatty, situated in the middle of the back, I found that the limits of the dorsal tumor were entirely undefined. The growth had no capsule; it blended insensibly on all sides with the apparently normal but redundant adipose tissue in its neighborhood, so that I was compelled to circumscribe it arbitrarily with the knife. The patient, who was to all appearance in good health, showed remarkably little recuperative power after the operation, and eventually did badly. In a similar case I should hesitate to resort to the knife.

It must have been a case of fatty tumor of this kind which Sir Benjamin Brodie reports as having been cured by *liquor potassæ*, for this drug has no effect upon an ordinary lipoma.

Under the type of connective tissue, *tumors consisting of cartilage and bone* are necessarily included.

The natural tendency of pure cartilage to become converted into bone is noticeable in these growths, and yet tumors consisting entirely of cartilage are not infrequent; and unmixed bony tumors are also quite common. The growth of pure cartilage, known as *chondroma*, is a tumor of hard, gristly consistence, presenting a nodulated surface, *which in most instances takes its origin from some part of the skeleton.*

The cartilaginous tumor in one of its forms was described and pictured by Cruveilhier, in his magnificent atlas of pathology, under the name of *osteo-chondrophyte*—a growth of bone and cartilage. In 1836 it was exhaustively studied by Müller, who gave it the name it has since borne—chondroma. Müller found that this form of tumor, in all its varieties, consisted mainly of two histological elements—namely, cartilage-cells, and a fundamental structureless substance in which the cells are imbedded; *in other words, that it was identical with normal cartilage.*

It presents *varieties*, of which the most noticeable is the *soft chondroma*, in which the fundamental substance is soft, like jelly, or thick synovia; but the cells remain unchanged.

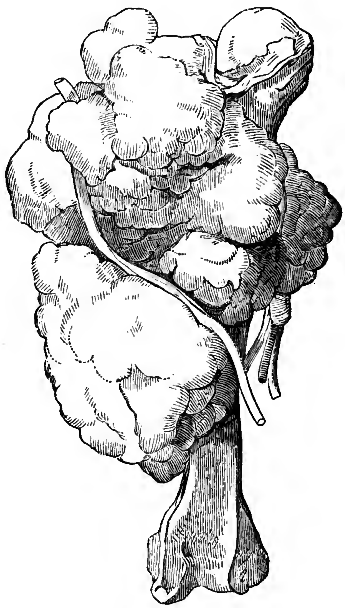
Müller subjected fragments of chondromatous tumors to chemical tests, and found that the hard variety always yielded chondrine on boiling, and the soft variety sometimes chondrine and sometimes gelatine.

These tumors, as a rule, are benign. Fig. 15 represents an enormous chondroma of twenty years' growth, involving the upper portion of the humerus, which was removed by Liston, of London, from a medical officer of the navy by amputation at the shoulder-joint. Besides the inconvenience of its bulk, this tumor caused great pain by the stretching of the large nerve that is seen crossing its surface. This exemplifies the only source of pain in chondromatous growths.

In one hundred and forty-one cases of chondroma

collected by Heurtaux,* one hundred and four were developed from the skeleton, and thirty-seven only oc-

FIG. 15.



Enchondroma of the humerus.

curred in the soft parts. In connection with the skeleton, its most frequent seat is in the *phalanges* and *metacarpal* bones of the hands and feet; *more than a third of the cases were situated here.* In the jaws, upper and lower, there were fifteen; connected with the bones of the pelvis, fourteen; the rest were developed at the ends of the long bones, and scattering.

The most characteristic development of chondroma is in the bones of the hand, which are its favorite locality, sometimes growing singly in a metacarpal bone or one of the phalanges, and at others presenting a number of hard, elastic, globular tumors. In these the

* "Nouv. Dict.," t. vii, p. 515.

growth takes its origin in some cases from the periosteum, and in others from the medullary cavity. In the latter case, the bony wall of one of the phalanges often expands into a thin shell, which sometimes may be indented by pressure and give a sensation of resiliency, with crackling, very much as in a bony cyst. This form of the disease has been called *spina ventosa*, i. e., wind-gall. *If submitted to operation early, the new growth may be scooped out and the phalanx saved.*

Chondromata connected with the skeleton are usually of slow growth, and are most frequently seen in young subjects. But it may occur late in life; and in some cases, when growing from the humerus, or femur, or pelvis, has reached a very large size, even late in life, in two or three years.

The disease would seem to be more grave in its import in proportion to the size of the bone in which it takes its origin. There is no recorded case, so far as I know, in which chondroma of the metacarpal bones or phalanges has manifested a tendency to malignancy.

This can not be said of chondroma developed near the knee-joint—in the femur or tibia, or in the pelvis. A cartilaginous tumor growing from the periosteum, or even free in the connective tissue, thrusts the softer parts aside so as to make a distinct capsule for itself of condensed connective substance. This external capsule sends septa or prolongations between the nodules of the tumor into its interior, and these convey its nutritious vessels. These penetrating septa of connective substance sometimes take on ossification, so that the cartilaginous mass becomes thus provided with a bony skeleton, justifying Cruveilhier's original title for the disease; *but its own proper substance undergoes conversion into bone only in rare instances, and the tumor is then called an osteo-chondroma.* The few cases of this kind on record have been mostly situated in the upper end of the tibia or lower end of the femur.

I once amputated the thigh at its middle for a large tumor of this kind, and the disease afterward returned in the portion of the femur that was left. The persistent growth of this secondary tumor caused such severe and constant pain that I subsequently removed the stump at the hip-joint. After a few years' respite, the disease again made its appearance in the os innominatum of the same side, and, by its gradual growth, invaded the cavity of the true pelvis, causing death ultimately, in ten years from its first appearance in the thigh, by obstructing the functions of the rectum. This was a recurrent ossifying chondroma.

Paget records a case of chondroma of the testis which was removed by castration, and *the patient subsequently died with well-marked cartilaginous tumors of the lungs.* The recent records of surgery show quite a number of cases in which a purely cartilaginous tumor has manifested this tendency to secondary diffusion throughout the organism; so that, from having been regarded as one of the most certainly benign tumors, chondroma has been proved to be capable of assuming the characteristics of malignancy.

This tendency seems to manifest itself especially in cartilaginous tumors *when they develop in the soft parts*, and by preference *when they develop in the testicle and in the parotid or its immediate vicinity.*

In the collection of cases already cited, of the thirty-seven located in the softer tissues, out of the aggregate of one hundred and forty-one, *fourteen* were in the parotid, or near it, *ten* in the testis, and *six only* in the connective tissue in *various* localities.

This curious fact should lead us to regard *cartilaginous tumors in these localities as very suspicious in their quality as to malignancy.* And it also suggests that some of the tumors in these localities, formerly called "scirrhous," in consequence of their *hardness*, *may have been chondromata.* It would seem that the more a chondromatous outgrowth is found at a distance

from its congeneric tissues of the skeleton, the more liable it is to develop a malignant character.

Chondroma has never been known to get well spontaneously in any of its forms, although it may possibly, in rare instances, cease to grow. It is favorably influenced by no medical treatment, and the knife is absolutely necessary for its cure. For obvious reasons, this remedy should not be deferred. When seated among soft parts and of recent development, the capsule by which it is surrounded facilitates its enucleation; and this should be thoroughly effected.

If a small bone is affected by the disease, and the case is seen early, it is always proper to try, by an exploratory operation, to remove the cartilaginous growth before resorting to amputation.

I once removed a well-defined chondroma the size of a large fist, growing from the body of the scapula, in a young woman, by sawing out a V-shaped section of the body of the bone, the broadest part of the section looking toward the base of the bone. About one third of this tumor, which was globular in shape, projected from the deep surface of the scapula toward the ribs. It presented small hemispherical projections of a pearl color and cartilaginous consistence, and was loosely adherent to the connective tissue surrounding it. The cure was apparently permanent.

Osteoma, or, as it is more frequently called, *exostosis*, is a purposeless bony outgrowth from some part of the skeleton. The typical exostosis is more or less spherical in shape, with a narrow base, or pedunculated.

According to their internal structure, these bony tumors are divided into spongy and cortical exostoses —the former consisting of ordinary cancellated bony tissue with a denser lamina externally, the latter being composed throughout of hard cortical bone. Besides these, there is the eburnated osteoma, in which the growth assumes the compact density of ivory, with *almost entire absence of blood-channels and cancelli.*

True osteomata are perfectly benign growths. They may take their origin from bone, periosteum, or cartilage, or they may form even in connective tissue. They are in some instances multiple ; but they rarely, under any circumstances, reach a large size. *Ossifying chondromata, and sarcomatous growths from the periosteum in the interior of which bony substance has developed*, are liable to grow to a large size and to assume a malignant character, but the true osteoma never.

There are bony growths of an irregular character often developed in connection with chronic inflammation of the periosteum and in the vicinity of diseased bones. These growths are also favored by gout and syphilis, and they are occasionally seen, in the form of bony plates, in the processes of the dura mater—the falx and tentorium—and sometimes, but more rarely, in the pia mater and arachnoid. These are not true osteomata, and are more properly called *osteophytes;* they have pretty certainly an inflammatory origin. A blow upon the cranium has been followed by a hemispherical elevation attended by obliteration of the diploe, and in some cases by eburnation.

Ivory exostosis seems to occur by preference in the orbit. It grows very slowly and sometimes becomes stationary, but generally requires removal if situated where its increase in size threatens to interfere with important neighboring organs.

The removal of exostosis, when rendered necessary, may be safely effected by means of fine saws, or by the gouge, chisel, and mallet. The only contra-indication to an operation is the possibility of injury to neighboring organs—as to a joint, or to the cranial contents.

Vascular tissue is intimately associated with connective tissue, even more obviously so than bone. Under this type, therefore, all unnatural outgrowths of the small blood-vessels are, in accordance with Lücke's classification, properly included.

Vascular tumors constitute a large and very important and interesting class: they are almost invariably congenital in their origin, and therefore directly referable to some deviation in embryonic development; occurring for the most part in infants, they come first under the observation of the obstetrician, and finally they are for the most part remediable, or at least amenable to judicious and skillful treatment.

Vascular growths present themselves in a variety of forms, some being entirely unchangeable and harmless, while others are liable to assume a serious character, and even to place life in danger. I will mention the more common names of some of these vascular tumors, and afterward discuss their pathology. I will then describe the peculiarities of each variety, and the treatment it demands.

The simplest form of vascular disease in this order of abnormal development is seen in the scarlet or purple patches of discolored skin, known popularly as wine-stains. These constitute, for the most part, simply unsightly marks, causing no other inconvenience.

In the next form the discolored patch of skin is elevated and irregular on its surface, constituting a positive scarlet or purple *outgrowth.* It may continue to grow, and is always liable to exaggerated bleeding, if the skin should be broken. This most common form in which the disease presents itself is generally spoken of as a *vascular nævus*—in popular language, a *mother's mark*, a strawberry birth-mark.

In another form there is a distinct *mass developed beneath the skin*, feeling often like a bundle of earthworms, and yielding under pressure as though it were sponge-like in consistence. In this variety the skin over the tumor may be perfectly natural and unchanged, but it not infrequently presents a bluish tint. Very often the skin immediately over the subcutaneous tumor presents the same red, elevated altera-

tion already mentioned. Sometimes the whole mass is *pulsatile.*

Again, some of these subcutaneous vascular tumors have cysts or solid masses contained in their substance in addition to the vascular element.

Finally, the larger arteries connected with these congenital vascular tumors take on progressive enlargement, and constitute a positive source of danger.

The *morbid anatomy* of all these vascular growths consists in *dilatation of capillary vessels*, liable to extend—on the one side to venous radicles, and on the other to arterioles; in new formation of capillaries in loops and tufts; in sacculation of dilated vessels—principally of veins; and in occasional rupture of a dilated veinule, or vein, with partial organization of the resulting *cavern.* These alterations or irregular developments in the normal vascular structure comprise all the morbid changes found in the microscopic study of these vascular growths.

The fact of *the actual new formation and growth of loops and tufts of capillary vessels, and a corresponding development of new connective tissue around them*, explains the nature of these tumors and their origin in excess, and in deviation and perversion, of embryonic growth and development. The new capillaries grow by the budding process, just as in granulation tissue; they form themselves into minute vascular, convoluted balls, and the substance of every *growing* vascular tumor is actually made up, in a large proportion, of these little granular masses of dilated capillaries.

As regards a correct name for this disease, which presents itself in such different forms, it seems hardly proper to speak of a patch of skin the color of claret wine, which may give to the finger passed over its surface no sensation of elevation, as a tumor; and yet the lesion of blood-vessels which explains its color is essentially identical, as regards dilatation, with that to which a fully formed tumor owes its existence.

The term *nævus*, or birth-mark, is also defective, for it is just as truly applicable to a patch of black pigmented integument covered with hair, or to an ordinary mole.

The names *angiectasis* and *telangiectasis*, applied to tumors of this class by the Germans and Italians, mean literally *dilatation of vessels*—nothing more. Now, the *budding process and the formation of new vessels*, when present, is in reality a much more important element in the disease than their *dilatation*, for *the former is always active and aggressive.* The appellation of angiectasis is therefore defective, for the disease includes something more than mere dilatation or ectasis; there is often *positive generation of new tissue.*

The French designate the disease, after Dupuytren, as *erectile tumor*, because it swells when held in a depending position, and shrinks when the arteries leading to it are compressed. John Bell compared one of the tumors he removed by the knife to a sponge saturated with blood, and describes its texture as resembling that of a cock's comb, or the corpus spongiosum penis. Paget avers that there is an exact resemblance between the two. Certainly most authors use the same language; but it must be remembered that this is a naked eye, and not a microscopic, resemblance that is spoken of.

Now, the term "erectile tumor" has been asserted by Robin to be "inexact," inasmuch as so-called "erectile tumors," as he says, have nothing whatever of the histological structure of normal erectile tissue.* Le Gros, a most reliable authority,† quotes Robin as having demonstrated, "after profound study and after having followed up their development," that the areolæ of normal erectile tissue are in reality enormously dilated capillaries. But, as I am informed by his for-

* "Dict. de méd. et de chirurg.," Paris, 1873, art. "Vasculaires."

† "Des tumeurs erectiles et leur physiologie," Paris, 1867, p. 8.

mer pupil, Professor L. A. Stimson, Le Gros regarded the presence of helicine or spiral arteries as the distinctive feature of the *normal erectile tissue*, and he demonstrates that these are brought into action by the influence of nerves, which are largely present; he shows, too, that the spiral arteries open directly into its areolæ or vacuoles. *These spiral arteries have not been recognized in any form of vascular tumor.* We must therefore consider the term "erectile" tumor as inaccurate.

Now, a well-marked disease with characteristic features, such as this we are studying, should have a distinctive name applicable to all its phases, even when it has not assumed the character of a tumor. It has seemed to me that the term *angeioma*—used first by Virchow—which conveys the idea simply of its vascular nature and origin, and, by the termination *oma*, of its place in the class of tumors or new growths—serves all the purposes of a name, and carries with it no wrong idea. *This term I shall therefore employ to designate all morbid growths heretofore spoken of as vascular or erectile, in whatever stage.*

Remember, therefore, as a summary of its morbid anatomy, that in every *angeioma*, whether its substance is made up only of dilated and occasionally varicose capillaries, or of additional new material in the form of vascular buds from pre-existing vessels, *there is also present more or less connective tissue* to hold together the tufts or granular masses of newly formed capillaries.

In studying more closely the variety of angeioma forming the discolored patches of skin known as wine-stains, it becomes evident that the abnormal condition of the integument consists entirely of dilated capillaries containing venous blood.* The arterial element, as a

*Follin (*Op. cit.*, t. i, p. 206) has seen varicose dilatations with the microscope in a wine-stain of the skin, and assured himself that the diseased vessels were true capillaries of the skin.

rule, is in no way involved in birth-marks of this class. They are not liable, therefore, to increase or grow. The same is true of all purely venous angeiomata. While they rarely get well spontaneously, as is so frequently the case with the more active nævi of a mixed or arterial character, they still more rarely take on any morbid action.

When the subcutaneous tissues are involved in venous angeiomata, there is often an increased deposit of fat in the meshes of the contiguous connective substance, probably from the slower current in the dilated venous radicles. This fatty accumulation leads also to obstruction in the larger venous branches, so that they become varicose, sometimes indeed burst, or are converted, by partial obliteration, into cysts.

Billroth rather regards rupture as a peculiar feature of the tumors which are made up mainly of veins, and these he habitually designates as "cavernous tumors."* In fact, the anatomical aspect of the few tumors of this variety which have been subjected to examination after removal justifies this designation.†

The tendency to the growth of connective and adipose tissue in company with dilated veins may explain, also, the congenital fatty tumors of the neck which are occasionally described as showing remains of vascular tissue; and it may also throw light upon the presence

* *Op. cit.*, p. 719.

† In such a tumor, removed from the upper part of the calf in a girl of ten, which was congenital and did not pulsate, Hulke describes "black-currant cysts," "cavernous tissue," and phleboliths (*vide* paper on Vascular Tumors in Muscles, by De Morgan, in "Med. Chirurg. Rev.," Jan., 1864, p. 187). Liston removed a similar tumor from the popliteal space of a boy of ten, also commencing in infancy ("Med. Chirurg. Trans.," vol. xxvi, p. 120). Gascoyen describes a congenital tumor of the parotid which contained phleboliths. It caused death at the age of forty-four by suffocation. The same patient had a nævus of the submucous tissue of the small intestine, visible through its peritoneal coat (London "Path. Trans.," vol. xi, p. 267, and xx, p. 205). According to Billroth, such tumors have also been found in the liver, kidneys, etc., of patients who had similar patches on the surface of the body.

of congenital cysts of the neck, adipose tissue having been present and subsequently absorbed. Billroth found a mass of dilated veins in the center of each lobule of a fatty tumor which he removed from the connective tissue beneath the scapula of an otherwise healthy young man.

Venous angeiomata, which we have found to be always congenital and, as a rule, stationary as to growth, are decidedly of less frequent occurrence than those of an arterial character. In one hundred and fifty-one cases of vascular growths collected and tabulated by Porta,* thirty-nine only were venous, and one hundred and twelve arterial. Of the thirty-nine venous patches, twenty were in the skin or immediately beneath it, and nineteen bore the same relation to a mucous membrane. On the other hand, ninety-four of the one hundred and twelve arterial tumors involved the skin, and only eighteen a mucous surface. So that venous growths evidently have a preference for mucous membranes; and the arterial tumors, which are far more numerous, occur for the most part on the external surface of the body.

As to the treatment of simple wine-stains, application is often made for relief of the deformity, but there is no remedy which has hitherto proved of much promise. It has been proposed to tattoo them with white lead tinted with vermilion. A plan proposed by Broca is, I think, the most hopeful. He blisters a small portion at a time of the discolored skin, removes the epidermis, and then paints the raw surface with liquid perchloride of iron, which, you know, unlike the subsulphate, is slightly escharotic. A smooth, black, horny crust results. This crust takes a long time to separate, but it leaves behind it a smooth surface of a lighter color than the original skin. This treatment acts by obliterating the dilated surface capillaries. Follin states that a nurse of one of the Parisian hospi-

* "Dell' angeiectasia," Milano, 1861, pp. 5 and 6.

tals was exhibited at the surgical society who had been decidedly improved by this treatment. The process is painful, but, if any treatment whatever is undertaken for this variety of angeioma, this plan seems to be the most promising.

It remains to be mentioned that, in exceptional and rare cases, birth-marks of this character, when complicated with any subcutaneous thickening, have been observed *to take on active growth at the period of puberty.* When this occurs, the arterial capillaries and arterioles are liable to become involved, and, in some instances, the peculiar disease to which Breschet gave the name of "cirsoid aneurism" has taken its origin in this way. Of this disease I will speak further hereafter.

We have next to consider the more vascular growths —usually spoken of as *arterial,* in distinction from the last class, which were called *venous.* The designation "arterial" is justified by the brighter and more scarlet color, and which the more elevated surface of the altered integument presents. It tends to active and thrifty growth by the development in its substance of new tufts of capillaries and a corresponding development of new connective tissue, often forming a tumor beneath the skin, and sometimes even developing a pulsatile character.

Angeiomata of this class are by far the most frequent of the vascular tumors. They comprised one hundred and twelve of the one hundred and fifty-one cases collected by Porta. Of these, ninety-four out of the one hundred and twelve involved the skin, and only eighteen a mucous surface ; and the great majority of them were congenital, or developed within the first year of life.

Although these tumors belong to the period of luxuriant growth of tissue—i. e., to early life—the great majority of them disappear spontaneously shortly after birth. This fact is to be borne in mind, for the

fears of an anxious mother might otherwise solicit officious and unnecessary treatment. Depaul, the eminent accoucheur, reports that no less than a third of the children born at the Clinical Hospital of the School of Medicine of Paris have vascular birth-marks, but that most of them disappear a few days or months after birth.

How is this result accounted for?

The connective tissue which, with budding capillaries, composes the bulk of the tumor, is stimulated to increased and more active proliferation by the rougher contact and bruising to which it is exposed after birth, and, *by its subsequent and positive contraction, the newly formed vascular tufts are constricted and obliterated, and the part returns to a normal condition.*

That this explanation is correct is proved by the facility and certainty with which these tumors are cured by exciting in them a moderate amount of inflammation.

Our simplest and best remedies act in this way: e. g., setons of ligature silk saturated with iodine tincture passed through the mass, or its perforation by means of red-hot needles. Even the pressure of a coin bound upon the growth when it is of limited size will sometimes effect a cure. A case is related of a faithful mother who compressed a vascular growth on the side of her baby's nostril with her finger and thumb until it disappeared.

When, however, a congenital angeioma continues to increase in size, means to arrest its increase should be unhesitatingly employed. It is not always easy to determine whether or not a vascular tumor is growing, for it is liable to vary in its rate of increase, and sometimes to become stationary, or even to recede. My late colleague at the New York Hospital, Dr. John Watson, in an excellent practical paper on this subject, has a case of a young lady in whom a congenital, bright scarlet tumor on the forehead, which had increased in

two years to the size of a quarter of a dollar and had become elevated and thrifty, stopped short in its growth without apparent cause, remained stationary for a year, and then "gradually shrunk and was effaced so entirely as to leave no trace."* In his latest work on surgery Holmes says: "In some cases, usually after an attack of grave illness, such as scarlatina or whooping-cough, even large nævi have been known to disappear altogether."† Gibson relates the case of a child with an erectile tumor below the angle of the jaw for which he had recommended an operation. But the child was seized with fever, which placed its life in danger, and after convalescence it was found that the tumor had disappeared.‡

On the whole, considering the safety and efficiency of the modern methods of cure, it is wiser, when in doubt as to the probable course of a vascular growth, to adopt curative measures, and not to trust to a contingency which, to say the least, is not likely to happen. This consideration is especially applicable to a tumor seated near one of the natural outlets, and liable, if it should grow, to involve the lips, nostrils, eyelids, or ears. The detection of a commencing pulsatile thrill in a vascular growth should be regarded as a warrant for immediate action.

The early cure of a growing angeioma is advisable, in view of the serious proportions which the tumor is liable to attain if allowed to go on unchecked. Mussey's account of the case of a huge erectile growth upon the scalp of a young countryman, in which he succeeded in removing the tumor by cutting around its base, affords an example of a neglected congenital vascular growth. He made his incision, circumscribing the diseased mass at some distance from its base by install-

* "Observations on Telangiectasis," "North American Jour. Med. Sciences," 1839, p. 26.

† "Prin. and Prac. of Surgery," London, 1875, p. 330.

‡ "Inst. and Prac. of Surg.," Philadelphia, 1825, vol. ii, p. 160.

ments, cutting but an inch at a time, and then rapidly tying the divided vessels which were entering the tumor from all sides, and most of them considerably enlarged, before making the next incision. By this method forty ligatures were applied in all, and yet the patient was much exhausted by the loss of blood; but he ultimately recovered, and the cure was permanent. This was carrying out the instructions of John Bell concerning this form of tumor—which he first called "aneurism by anastomosis"—namely, in cutting them out, *never to cut into them.*

In a similar case of neglected angeioma, involving the lip, Mason Warren, after tying both primitive carotids, was compelled to employ successive ligatures upon the substance of the tumor before he succeeded in its entire extirpation.

What, then, are the best means at our command for the cure of a young and growing vascular tumor? In the past time, extirpation by the knife was regarded as the natural remedy, or, to avoid undesirable hæmorrhage, caustics were substituted—especially when the tumor was small. But these remedies are hardly applicable where the eyelids, lips, or the openings of the nostrils are the seat of advancing disease. Here the ligature, in its different modes of application, has been a favorite resource, as by it the morbid growth may be effectually destroyed without danger of hæmorrhage, and with less deformity from the resulting scar. But still better results have been gained by the *actual cautery* applied in such a way as to produce inflammation and subsequent contraction of the connective-tissue element of the tumor, and thus to constringe and obliterate the enlarged and growing capillaries. In this way, by repeated operations when required, the disease is in most cases curable with but trifling cicatrix.

This end is most conveniently accomplished by perforating the tumor with metallic needles heated to a cherry-red—a device credited to a New York surgeon

named Bushe. I have employed this remedy largely, and with very great satisfaction. The benzine cautery of Paquelin offers great facilities for its application; but, in its absence, an ordinary alcohol blow-pipe will be found sufficient for heating the needles set in wooden handles, which are furnished for that purpose by the instrument-makers. There are few vascular growths which are not safely curable by this remedy when judiciously applied at an early stage. The principle on which it acts is to be kept in view—namely, to cause cell-proliferation and subsequent contraction of the connective-tissue element of the tumor; and, to accomplish this with as little scar as possible, it is often wiser to do the operation by installments, awaiting the result of one application of the hot needles before repeating it.

It is as well to know that erectile tumors *do not contain many nerves;* their sensibility, indeed, bears no proportion to their supply of blood; they are not easily excited to inflammation; but, when they become once thoroughly inflamed, they have a very decided tendency to slough. Of course, a tumor may be destroyed at one application if the cautery be freely enough applied; but this constitutes another operation, which would be followed by a more unsightly scar.

Many substitutes have been devised for the actual cautery in this disease as an inflammation-producing agent, and also as a destructive agent substituted for the knife; and these require a word of notice.

After a good deal of observation of its effects, I have come to regard *caustic potass.* as a rather severe and barbarous remedy; it has held its place mainly through the prestige it gained when there were no better caustics in use. Its application causes much pain, and, in consequence of its deliquescence, it is not easily managed. I have seen more than one imperfectly cured nævus surrounded by unnecessary and unsightly scars—the result of want of familiarity with its destructive power; and,

withal, it has this great disadvantage, *that it is incompetent to coagulate the blood.* This is not true of *nitric acid*, which is but slightly painful, is easily managed, and leaves a smooth scar; but it is purely a caustic, and has little or no power to excite inflammation.

Watson* relates a case in which many years ago Mott used caustic potash upon a little vascular nævus on the cheek of a baby. It failed to cure, leaving an ulcer which healed only at the end of eight weeks. Then Bushe applied heated needles on two occasions; but no cure followed. Finally, Stevens passed a seton of several silk threads, which remedy brought about, very slowly, its suppuration and cure. This tumor was evidently tending to increase *beneath the skin* more rapidly than was at first recognized—*a frequent cause of disappointment.* Moreover, it is not desirable to provoke suppuration, a result which rarely follows the judicious application of the heated needles. Billroth, who does not even mention caustic potash, thinks that the use of strong nitric acid ought to be the general method of cure for superficial angeiomata.†

Chloride of zinc—made into a paste with flour and dried in the form of thin rolls, which, when cut into proper lengths and sharpened, can be thrust safely into a subcutaneous tumor, each through a minute incision of the skin, in sufficient numbers—may be relied upon to destroy its vascular character; I say *safely*, because this caustic promptly coagulates the blood. The French call these sharpened rolls of chloride of zinc *flèches*, or arrows. Solid tumors have been surrounded by them in sufficient numbers to cut off its blood-supply and make the tumor slough out. Maisonneuve advocated this method of extirpating cancerous tumors.

This is an improvement upon the method of Lallemand, who stuck a subcutaneous nævus full of minute pins and left them in place for a week. The characteristic indisposition of the vascular tissue to take on

* *Loc. cit.* † *Op. cit.*, p. 724.

inflammation made it necessary to repeat this operation, but it is stated to have been finally successful.

Tincture of iodine is one of the mildest inflammation-producing agents, and its repeated application for a period of time has been known to cure vascular spots confined entirely to the skin without scar. Combined with compression, I know that this remedy is advised for birth-marks by accoucheurs before the surgeon is consulted, because it is simple, safe, and well known; but I know, also, that it often fails. The blister, followed by the perchloride of iron recommended by Broca for wine-stains, acts somewhat in the same way, but it is more powerful. Macke's *solution of corrosive sublimate in collodion* (gr. iv to ℥j) is still more severe; it will kill some tissue, but the crust, if allowed to fall spontaneously, is less likely to cause pus, and may be followed by a smooth scar.

Dr. Richardson, of Dublin, praises the *ethylate of sodium* as an escharotic in surface nævi. He says it forms a crust, and leaves no scar, and details a number of cases—one involving the eyelid—which were successful.*

(The application of mono-chloracetic acid to the surface has been recently introduced, and has given good results.—Ed.)

Vascular nævi have been cured by *compression by means of a spring truss* against underlying bone, as in the scalp. Where there is no bone for counter-pressure, *a clamp of sheet-lead* has done good service. Even *a coin sewed in flannel* and kept in place by crossed strips of plaster has had the credit of cure. Dieffenbach is said to have effected cures by *compresses saturated with alum.* But it must always be remembered that *a majority of nævi get well spontaneously.*

In consequence of its ingenuity, the idea of employing the irritating property of the *vaccine virus* to cure vascular nævi in children has found great favor; but its

* London "Lancet," January, 1881, p. 168.

application is limited, and its effects in practice have proved uncertain. The too readily escaping blood tends to wash away the poison, which, to be effective, must be inserted at numerous contiguous points—upon the growth itself, and not around it. Nélaton proposed to saturate threads with the lymph and then carry them through the growth as setons. In subjects already vaccinated, *croton-oil*, or a *strong solution of tartar emetic*, have been both suggested as substitutes for the vaccine virus; but these substances have no coagulating power like chloride of zinc, and are less certain and manageable as to their action.

Setons saturated with perchloride of iron have also been highly praised, especially by Mr. T. Smith, of St. Bartholomew's, and surgeon also of a child's hospital in London, who published several excellent clinical lectures "On Nævus" in the London "Lancet" in 1867. The best material for setons is ordinary darning-cotton, which absorbs more of the iron solution. This should be introduced by means of a disproportionately large needle with a large eye, so that the solution shall not be pressed out of the thread. Mr. Smith leaves them in place about a week, by which time each thread will have produced a slightly suppurating track.

The *injection* of the perchloride, and also of the subsulphate of iron, by means of a subcutaneous syringe, was at one time regarded as a very promising mode of cure of vascular growths; but experience has demonstrated that their use is not only unsatisfactory and inefficient, but dangerous. The needle-like nozzle of the syringe usually lodges the coagulating fluid in the connective tissue of the tumor and not in its capillary vessels, and the result shows a small, hard, black nodule, which, instead of being absorbed, remains *permanently*. When the point of the needle enters a large vessel, *there is danger of embolism.*

The following case, recorded by Mr. T. Prigdin Teale,

of Manchester, England,* is instructive: "In a rapidly increasing nævus as large as a billiard-ball, in a young child, several punctures were made, and a few minims of the perchloride were introduced at each puncture. The greater part of the tumor became rapidly solidified. Three weeks later the effect of the injection had passed off, and the tumor again began to increase rapidly. I therefore repeated the injection. After three or four punctures and injections of the iron, the child looked pale, became convulsed, and died in a few minutes."

Billroth, in relating a case in which he was employing heated needles in repeated applications for an erectile tumor involving the nose and whole thickness of the upper lip, says he prefers them to the injection of the perchloride, because the latter sometimes causes suppuration and gangrene, and because the cannula of the syringe is so liable to be stopped by blood-clots.† Broca advises that a very dilute solution of the perchloride be used, and very numerous punctures, hoping thus to avoid accident.

But the constantly recurring fatal cases after injections of the perchloride should deter a cautious practitioner from employing this, or any other similar remedy, as a forcible injection. Paget ‡ records a case of instantaneous death after injection into a nævus of a small quantity of diluted liquor ammoniæ: "The instant the fluid was injected, the child had one slight convulsion, and was dead." Mr. T. Smith, in his Clinical Lectures, refers to a case in which, after the injection of five minims of the perchloride, "the child shrieked out, had a single convulsion, and was dead." And to another, in which death occurred in fifteen seconds after injection of the perchloride into a nævus of the cheek. It was found, on post-mortem examination in this case, that the point of the needle had penetrated a small branch

* "Med. Chirurg. Trans.," vol. l, p. 62.

† *Op. cit.*, p. 725.

‡ "Lond. Med. Gazette," 1837.

of the transverse facial vein. "The blood was found coagulated in this vein and in the venous system down to the right side of the heart—which was filled with a firm clot." Again, a child had difficulty of breathing a day or two after injecting a subcutaneous nævus on the face with perchloride of iron, and shortly died. The lung-tissue was found consolidated and inflamed in patches—due, it was suspected, to embolism of the pulmonary capillaries—not enough of the coagulating injection having got into the blood to solidify that fluid in the right side of the heart.

Another case is more recently reported in which a "nævoid tumor the size of a small nutmeg, on the right ala nasi, was treated by injection of the perchloride, under chloroform. The child's face and hands at once became blue, and the pulse and breathing became embarrassed. Temporary recovery and relapse alternated several times, but the child finally died at the end of the third day." A clot was found stretching from the right internal carotid artery along the middle cerebral artery of the same side. The anterior portion of both lobes of the cerebrum was reduced to a soft pulp.* Bryant, in his Surgery, also refers to a fatal case.

These examples should warn us against the use of so dangerous a remedy.

The *ligature* is to be preferred in the treatment of arterial tumors in which there is a narrow or constricted base, especially if the portion of skin involved by the disease is large in proportion to the subcutaneous mass of the growth, so that it may be sacrificed with propriety. To dissect flaps of unaltered skin from a subcutaneous tumor and then to ligate the tumor involves the necessity of waiting for the constricted mass to slough ; and meanwhile the flaps shrink and the patient is exposed to all the dangers of an open wound. When the skin is sacrificed, the resulting scar is ren-

* James F. West, F. R. C. S., Senior Surgeon to Queen's Hospital, Birmingham, in London "Lancet," March, 1874, p. 402.

dered smaller than would be supposed by the puckering of the ligature. In parts that are movable and well supplied with connective tissue beneath the skin, the cicatrix contracts greatly after the use of the ligature, and in children, as a rule, it tends to grow out with age. So that, unless the tumor is so situated as to threaten deformity by contraction after its removal, as when the lower eyelid, for example, is involved, the scar following ligature of a nævus is rarely a cause of regret. The fear of the scar is the principal objection to the ligature, which, in some one of its numerous forms, will be pretty certainly found useful; as an objection it is usually overrated. If strong material for ligature is employed, and it is drawn very tightly, the pain does not last long.

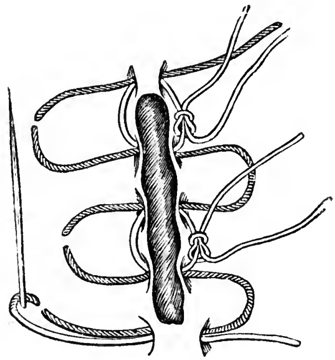
The simplest form of ligature is that usually employed in strangulating a hæmorrhoid, in which the base of the tumor is transfixed by a needle carrying a double ligature, the needle cut out, and each half of the tumor separately strangled. For a larger tumor, a second needle might be passed through its base at right angles with the first and the adjacent ends of the ligatures tied while the rest are being tightly held by an assistant. Pins previously passed beneath the base of a tumor facilitate pedunculation and accurate strangulation by ligature. For a large tumor, elongated or irregular in its shape, the ingenious method devised by Rigal (Fig. 16), which requires no description, is by far the best. Its application is rendered easier if half of the double ligature be stained black.

There are rare and exceptional cases in which a vascular birth-mark, after years of entire quiescence, takes on activity and tends to increase. This circumstance should be noted, for it renders an operation for the obliteration of every such growth, which does not get well spontaneously in infancy, more obligatory upon the surgeon. The rather sudden occurrence of active growth in an apparently stationary and harmless birthmark of this character has been observed to take place

by preference about the period of puberty in both sexes.

Not only may active growth show itself in the form

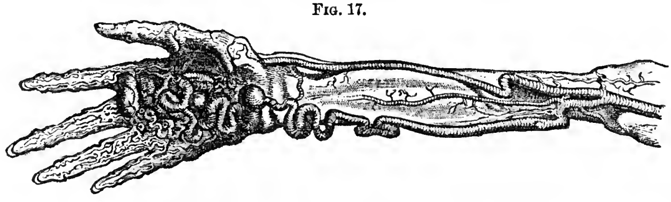
Fig. 16.



Method of treating a vascular tumor by ligature.

of a tumor—amenable to the modes of cure already described—but also in a curious tendency to arterial dilatation of the neighboring vessels accompanied by degeneration of the arterial walls, and mainly in those which bring blood to the focus of the disease. These arteries become not only dilated and thin-walled, but also tortuous and convoluted, as though they were increased in length as well as in caliber, and a distinct aneurismal murmur is developed in them. This change

Fig. 17.



Tortuous arteries of a cirsoid aneurism of the fore-arm.

advances from the capillaries along the arterial branches until it reaches the larger arterial trunks. Fig. 17

represents the arteries of the fore-arm in this dilated and tortuous condition. This curious disease was first formally described by Breschet, in the third volume of the "Memoirs of the French Academy of Medicine," under the name of *cirsoid aneurism*—i. e., aneurism resembling a varicose vein. It is a very grave affection, and not readily curable. Systematic pressure and ligature of the main arterial trunk supplying the area of dilated vessels are the most promising palliatives.* *But the vessel must be still uninvaded by the disease at the point at which the ligature is applied*, or the occurrence of secondary hæmorrhage may defeat the object of the operation. This event led to a fatal result in the first recorded case in which it was sought to cure this disease by ligature of an artery leading to it —the case of Catherine Micart, related in the classical essay of Breschet, in which Pelletan tied a *dilated* occipital artery for cirsoid aneurism involving the ear which had been the seat of frequent loss of blood; and secondary hæmorrhage from the site of the ligature, which could not be controlled, caused her death.

I have seen this disease in a growing girl. It had commenced in the middle finger, and was slowly advancing up the fore-arm. Systematic pressure was advised in this case by the late Valentine Mott.

Broca asserts that the dilated condition—similar to that of a varicose vein, which gradually creeps along from the smaller to the larger arteries in this formidable disease—is explained by failure of nutrition in the arterial coats *in consequence of a withdrawal of their normal tension.* The enlarged aggregate capacity in an area of dilated capillaries supplied by a given arterial branch relieves the walls of this artery of the tension necessary for their healthy nutrition. The absence of the friction of the normal capillary circulation takes off the habitual distention—the habitual necessity for con-

* Preference is now generally given to extirpation of the tumor or to interstitial injections of the perchloride of iron.—Ed.

stant dynamic contractile effort—and the arterial walls consequently deteriorate in textural quality.

The same dilatation, according to Broca, overtakes the brachial artery in cases of traumatic aneurism at the bend of the elbow, and from a similar cause, namely, the too easy escape of its blood through a direct and free opening into a large vein, instead of through a narrow and complicated system of minute capillaries.

The following case was one of great interest to me: A young girl of twelve had a congenital vascular patch just under the hair on the right side of the forehead, which had attracted but little attention, when an accidental scratch with the comb one day set it bleeding. The physician in charge found difficulty in checking the hæmorrhage, and, after failing with milder means, he concluded to tie a large branch of the temporal artery, which was pulsating rather strongly within a short distance. Secondary hæmorrhage, which could not be permanently controlled, came on in a few days at the point of ligature, and the late Kearny Rodgers was called in consultation. This excellent surgeon proceeded at once to tie the right primitive carotid, and, by persevering with pressure at the original points of hæmorrhage, finally succeeded, with much delay, in getting the original wounds all healed.

Five years later the young lady was brought to me with a series of pulsating tumors involving several branches of the right temporal artery, the main trunk of which, just in front of the ear, was at least four times its natural size. There were some cicatrices, but no surface discoloration of the skin—merely a bluish tint over the tumors. Numerous tortuous arterial branches had developed themselves in and beneath the skin of the forehead, especially toward the brow and right upper eyelid contiguous to the site of the original diseased patch; and these parts were puffy and tumid and obscurely pulsatile. This swelling could be reduced by pressure, and gave the idea that it was due to a mass of

dilated vessels within; but the varicose dilatations of the larger arterial branches, some of which were as large as pullets' eggs, contained only fluid blood. Everywhere in the neighborhood of the enlarged vessels a remarkably distinct vibratory pulsatile thrill was perceptible to the fingers, and a corresponding murmur to the ear. The patient complained of strange feelings in her head, and of great annoyance from a constant roaring in the right ear. Besides the dread of uncontrollable bleeding from accidental injury, the remembrance of her former wound being still vivid, the patient's symptoms were all increasing, and she was urgent in her demand for relief. This I decided could be most certainly secured for her by placing a ligature upon the remaining carotid.

By this measure all pulsation and murmur were entirely arrested; but, after three or four weeks, they again became perceptible, at first very faintly, and they never reached the same extent as before the operation. This latter was borne well, and no unpleasant symptoms whatever were produced by the obliteration of both primitive carotids. But it was evident that the disease was only arrested by the operations, and not cured. It returned, but to a limited extent, and increased so very slowly that the patient thought herself well enough to marry within a year or two. I saw her occasionally for five or six years after this, always complaining of noises and queer feelings in her head, but presenting no serious evidences of advance in the disease. I tried several devices in the way of compression in this case, among the rest a double-spring truss, the pads making pressure one in front of each ear; but the advantage secured was not very positive.

I have related the case in order to show one of the rarer results that may follow when an angeioma is allowed to go uncured. There is no doubt in my mind that the starting-point of this varicose disease of the arteries was a vascular birth-mark of insignificant pro-

portions, and that its early destruction would have saved all subsequent trouble.

Here is a case which illustrates another possible contingency: The elder Warren, of Boston, was consulted by a lady of forty-five for a supposed cancer situated upon the hip. He found a large fungous ulcer, with a propensity to bleed on the slightest interference, seated upon an elevated base. The peculiar feeling of the mass underlying the ulcer, and the fact that it could be very much diminished by pressure, led him to recognize it as an *erectile tumor*. There had always been a small vascular birth-mark on this spot, which had begun to increase within four or five years. Warren cut it out, with the result of a permanent cure.

In French works on surgery the term *fungus hæmatodes* is used to designate an ulcerated erectile tumor like that just described. English authors, on the other hand, following Hey, of Leeds, apply it only to soft cancerous tumors of rapid growth.

The eminent surgeon of Boston whom I have just quoted mentions also an instance in which a contused scalp wound in a boy of seven resulted in the production of a vascular erectile tumor, which was cured, subsequently, with some difficulty. These cases will serve as an answer to the question as to whether such tumors ever make their appearance in after-life without any evidence or suspicion of a congenital source of origin. There is reason to believe that this is the case, but in very rare instances; and these always, I may add, carry with them a suspicion of cancer.

I have lately several times employed the term *aneurism*, and on each occasion as applied, somewhat equivocally, to an exceptional, or at least to a rare, form of disease. It is thus loosely employed by surgical writers whenever a tumor presents either a pulsatile character or a thrill or murmur—such a murmur, in fact, as may be produced at any time by moderate pressure made at will upon any large arterial trunk—the murmur ceas-

ing when the pressure is removed. It is well to bear in mind, therefore, that the term aneurism has, nevertheless, a distinct and well-defined signification of its own. It is correctly applicable only to a pulsating tumor containing fluid, *situated upon an artery and communicating with its caliber.* This definition of aneurism is accepted by the best authorities. We generally speak of a pulsating tumor, but the term is still strictly applicable to a tumor situated upon an artery and communicating with its caliber, even when its pulsation may not be recognizable, or after it may have ceased through solidification of its usually fluid contents by coagulation of blood within it.

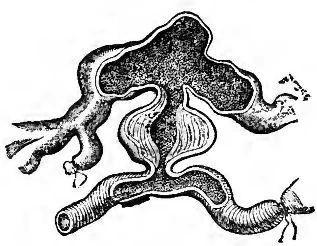
The fanciful designation, aneurism by anastomosis, applied by John Bell to a pulsating "erectile" tumor, is therefore inexact; the tumor is not an *aneurism;* it is an *angeioma.*

In like manner, the term *aneurismal varix* is somewhat equivocal. It was originally given to the enlarged, tortuous, sometimes pulsating vessels which are begotten as the consequence of an abnormal communication between an artery and a contiguous vein, where the arterial blood has free access to the vein, or *vice versa.* In former times, when the operation of venesection at the bend of the arm was so common, this condition was not of rare occurrence; it resulted from wound of the brachial artery by the point of the lancet after the latter had transfixed the vein lying over it. As the operation was done habitually by barbers and persons ignorant of anatomy, the frequency of this accident is readily explained. The dilatation and pulsatory thrill in the branches of the wounded vein seemed to justify the appellation of *aneurismal varix* applied to them. Again, as Broca has said, the branches of the wounded *artery,* which is habitually propelling its blood through an abnormally free outlet, themselves become thin-walled and dilated *through lack of tension resulting from the leak.*

The excessive and circumscribed dilatations which occur at points in the course of the altered arteries in cirsoid aneurism may justify the use of the word aneurism—in accordance with the definition I have given you; but it is only distinctly intelligible when qualified by the term *cirsoid*—which means, literally, as you know, *resembling a varicose vein.*

The meaning of the term *varicose aneurism* will now also be rendered clear; for, although this affection is caused—like the original aneurismal varix—by a wound inflicted simultaneously upon a vein and an artery, by which their currents may commingle, there is in the varicose aneurism an actual tumor formed at the moment of the wound by the escape of blood into the contiguous connective tissue, which tumor is situated upon the artery and communicates with its caliber, as seen in Fig. 18. The term aneurism is therefore correctly used here; and the prefix "varicose" is justified

FIG. 18.



Varicose aneurism.

by the dilatation and thrill which result in the branches of the wounded vessels from the commingling of the arterial and venous currents.

The term *arterio-venous aneurism* is at the present day very generally applied to all the conditions liable to result from the simultaneous wounding of a vein and an adjacent artery. Although it may not be always strictly accurate, it is intelligently comprehensive, and conveniently does away with the necessity of specify-

ing, in a given case, whether an arterio-venous lesion is an aneurismal varix or a varicose aneurism ; in either case it is arterio-venous in the commingling of blood-currents.

Under the type of embryonic connective tissue we have next to take up a most important class of tumors, presenting many different features, but all properly included under the denomination of *sarcoma.*

The *sarcomata* are by no means uncommon tumors ; they are complex in their anatomy, various in their forms, and obscure as to their prognosis ; and yet we know enough of their nature to make them, as a class, exceedingly interesting.

The name *sarcoma*, which is taken from the Greek word signifying flesh (σαρξ), was not suggested by human flesh, for the color and appearance of a sarcoma generally resemble much more the raw muscular tissue of the rabbit, chicken, or lobster. There is only one variety of it, the *myeloid*, which has the color of human muscle.

Anatomically, a sarcomatous tumor consists entirely of cells and blood-vessels held together by connective tissue, the latter being variable in its amount and quality.

The typical cells of a sarcoma are small and round, closely resembling those of "granulation tissue." In fact, the representation of granulation tissue with which you are familiar would pass for a specimen from a round-celled sarcoma. According to Rindfleisch, "the minute structure of a sarcoma belongs to the tissues to which we give the name of *inflammatory neoplasm.*" Its cells certainly resemble leucocytes, young pus-cells, and lymph-cells, and possess the "indifferent" quality ascribed by Huxley to these spherical masses of protoplasm, *together with a capacity for the most rapid and indefinite proliferation. But there is a certain something inherently wrong in their quality, for they are incapable of developing beyond the stage of cells and*

cell-growth. We shall meet with them as fusiform or spindle-shaped cells, and as giant-cells with multiple nuclei—the *myéloplaxes* of Robin; but *they are incapable of developing into tissue.* According to Lücke, they possess the *amœboid* power of movement, like leucocytes, and are capable of "wandering" indefinitely; and this explains their power of disseminating themselves. The same authority asserts that the reason why sarcoma does not contaminate the lymph-glands in its neighborhood is simply *because its cells are so small that they pass* through the glands without being arrested; but they reach the lymph and blood-streams from their point of origin, and certainly, in many instances, sow themselves generally throughout the organism. You may infer from this, at least, that the general absence of glandular contamination in sarcoma is no proof against its power of self-dissemination, and *that it is not correct, in general terms, to speak of this tumor as benign.*

In connection with their anatomy, it is proper to notice the several varieties of form in which sarcoma presents itself.

The typical tumor heretofore spoken of is known as the *round-celled sarcoma.* The *spindle-celled sarcoma* is identical with the "fibro-plastic tumor" of Lebert and the "recurrent fibroid" of Paget. The *giant-celled sarcoma,* so named by Virchow, is the "*tumeur à myéloplaxes*" of Robin, the "myeloid" of Paget. When developed in the delicate connective tissue of the nervous centers, it is called *glio-sarcoma;* in the meshes of a myxomatous fibroid, *myxo-sarcoma.* In connection with the bony tissue, it takes the name of *osteo-sarcoma;* when originating in a lymphatic gland, it is known as *lympho-* or *adeno-sarcoma.* When pigment granules are deposited in the interior of its cells, it becomes a *melano-sarcoma.* Finally, when its blood-vessels are in excess, it is spoken of as a *vascular sarcoma.*

Each of these varieties has at some time been regarded and described as a distinct and separate form of tumor, for each of them has well-marked characteristic features. This power of grouping together growths so dissimilar in many of their peculiar aspects into one family of undoubted parentage, we owe to the recent advances in our knowledge of histology and embryology.

Sarcomatous tumors take their origin always in the connective-tissue element, whence their vascular supply is also derived; they are consequently liable to grow from any part of the body. They occur at all times of life, and may even be congenital. In early life they grow very rapidly, and are liable to grow into the huge masses of so-called "medullary sarcoma," or "encephaloid cancer" so frequently encountered in children. In advanced life their progress is slower; they are harder in consistence, and bear more resemblance to carcinoma, from which they are usually distinguishable by the absence of glandular contamination.

A *round-celled sarcoma* of the typical variety and of recent origin presents itself as a well-defined tumor, generally globular in form and more or less firm in consistence; if seated in a gland, in early life, it is soft; in an elderly subject, harder; but always elastic, and not infrequently yielding at points a sensation of false fluctuation. It is surrounded in the earlier stages of its growth by a pseudo-cyst of connective tissue which has been pushed aside and condensed by its pressure while growing, and is consequently removable, at this period, without much difficulty. When not deeply seated, the skin over its surface is unchanged; but, as it increases in bulk, enlarged superficial veins make their appearance, *the blood being forced into them by the pressure of the tumor upon the deeper venous trunks.*

Of the progress of this variety of sarcoma it is not easy to give a correct general description. There are good authorities who say that its tendency to become

malignant is exceptional; others say that it is to be dreaded. My own experience is that, when not early taken out, these tumors almost invariably assume the features usually ascribed to soft cancer, growths of a similar character appearing elsewhere before death, which takes place in two or three years. *I think that they should be removed as early and as thoroughly as possible, and that, on the whole, the chances are in favor of their return*, either locally or generally; perhaps both.

The *spindle-celled sarcoma*, or "recurrent fibroid," is, in a general way, more benign, as its inchoate tendency to develop into fibrous tissue would lead us to believe. It does not "sow itself" generally, like its round-celled prototype, but is very liable to return at its original site at intervals of a year or two, or perhaps at first after a still longer interval. Ultimately it is fatal in a certain proportion of cases; but in what proportion exactly, their usually protracted duration makes it very difficult to determine. Billroth mentions a case in which a "sarcoma with fusiform cells" was removed from over the occipital bone five times in twenty-three years, the last two operations having been done by himself. The man finally died at forty-five, the occipital bone having been almost entirely destroyed by the tumor.

The *myeloid sarcoma* is a very-well characterized, softish tumor, resembling in its internal appearance half-organized blood-clot, growing by preference from the jaw-bones, where it has been described under the name of *epulis*. A French surgeon* collected forty-seven cases of this peculiar growth, of which fifteen were seated in the upper jaw and fourteen in the lower, and the rest in the cancellated extremities of the long bones, where it has been described as "spina ventosa," a name also applied to chondroma. Myeloid sarcoma is a disease of early middle life, occurring most frequent-

* Eugène Nélaton, Paris, 1860.

ly between twenty and thirty. According to Rindfleisch, it grows from the bone *beneath* the periosteum, and from the cancellated structure by preference, but not from the periosteum itself. This tumor—which was called "fungus hæmatodes" by Dupuytren, and which certainly, with its deep-red color, looks to the naked eye more like a malignant growth than any of the other sarcomata—often returns when imperfectly removed; but, according to E. Nélaton, when the bone from which it grows is thoroughly cut away and cauterized, it never comes back. Some practical surgeons, however, dissent from this opinion. Spindle-cells are found in some specimens associated with the giant-cells, which latter, in fact, means nothing more than an abortive attempt at development. These tumors are generally vascular, and are liable to bleed freely during and after removal, and the thermo-cautery might prove useful. In my personal observation, when thoroughly removed the cure has been permanent in two or three instances.

The name *glioma* is applied to a rare variety of fibroma which grows from the delicate connective tissue that holds together the elements of nerve-substance in the brain and retina—the neuroglia; and in the meshes of this structure the round cells of sarcoma are, as far as I can judge, in most cases developed, constituting a *glio-sarcoma.*

In a man of fifty, who died comatose after a series of brain symptoms extending over many months—among which irregular epileptic seizures, beginning by jerking of the head to one side and occasional mental derangement, had been most prominent—I found a growth larger than an ordinary hen's egg, and more solid than the cerebral substance which it had replaced, situated in the center of the anterior lobe of the left hemisphere. The substance of this tumor consisted mainly of small round cells, apparently of embryonic tissue. The tumor was, in fact, a round-celled glio-sarcoma.

The tumors of the eyeball in children, formerly

called *fungus oculi*, are glio-sarcomata, taking their origin from the retina. I learn from my colleague, Professor Noyes, that a certain proportion of these tumors are permanently cured by removal of the eyeball.

The title of *myxo-sarcomata* was given by Billroth to myxomatous tumors containing cellular elements imbedded in mucoid material—as an inter-cellular substance. These tumors have also been described as *colloid*, from the resemblance of their semi-fluid contents to soft glue. They resemble soft chondromata, which, however, show well-marked cartilage-cells under the microscope. Billroth speaks of their cells as star-shaped, tending to multiply in numbers without development, and to form giant-cells with multiple nuclei. The presence of mucoid or colloid substance in a tumor seems to have little significance as regards benignity or otherwise; it means in many cases, most probably, regression or degeneration. A myxo-sarcoma can not be regarded as otherwise than suspicious in character, and should be removed, if possible, without delay.

Besides the blood-colored myeloid tumors already described, sarcomatous growths of the ordinary paler tint take their origin in bone, either centrally in the medullary canal or externally from the periosteum. When growing from within, they give rise to fusiform expansion in the shaft of a long bone, the external bony shell, as absorption goes on from within, being deposited from the periosteum and becoming at some points quite thin. Such growths, to which the name of *osteo-sarcoma* is properly applied, occasionally fail to return after amputation.

In a certain proportion of sarcomatous growths, developed in the interior of a bone, there is an excessive development of the vascular element of the growth, with enlargement of the capillaries and arterioles, giving rise to a pulsatile thrill simulating that of aneurism. This condition can not be correctly called aneurism; it is simply a pulsating tumor of bone, and is a not very

infrequent occurrence. In a tumor of the pelvis of this nature the primitive iliac artery was once ligated by Guthrie under the conviction, shared by several eminent surgeons, that he was dealing with an aneurism. Although uncertain as a curative measure, the ligature of an arterial trunk supplying a pulsating sarcoma of bone is a remedy to be tried ; but, when seated in a limb and removable by amputation, this is the operation to be preferred.

I once saw a case, with my former colleague, Dr. Charles D. Smith, of pulsating tumor involving the os calcis in a young lady, in which this surgeon tied the femoral artery with only temporary benefit, and afterward removed the limb. Its main artery was carefully injected. The great preponderance of blood-vessels and the softening and disappearance of the normal bony tissue were the prominent features noticeable at the seat of disease. The increase of bulk in the growth was inconsiderable. *It is well to remember, then, that a pulsating tumor of bone is most probably a vascular sarcoma originating in its cancellous structure.*

External sarcomatous growths from bone—what are usually called "periosteal growths"—increase in size slowly at first, but in most instances, according to my observation, they assume, sooner or later, all the characteristics of medullary sarcoma, or soft cancer. In the huge tumors occasionally occurring at the upper half of the femur, and in those growing from the pelvis, the diagnosis lies between osteo-sarcoma and ossifying chondroma. An ossifying chondroma is often only distinguishable from a sarcoma of bone by its usually slower growth.

Sarcoma developed in a lymphatic gland—*adeno-sarcoma*—is usually a round-celled, rapidly growing tumor, occurring in early life, and located, by preference, in the neck or axilla. Sometimes several glands are involved, and then the mass assumes a lobulated form. It is usually rather globular in shape, of soft-

ish, elastic consistence, and not infrequently yields at points a sensation of false fluctuation. This is due to the slender amount of connective tissue in which the cells are imbedded; and these, consisting of protoplasm, glide against each other and yield to pressure almost as readily as a thick fluid. These tumors are at first enveloped in a pseudo-cyst, and are easily taken out; later they grow more rapidly, and infiltrate the surrounding parts. From this circumstance, and the very large size they are liable to attain, their removal is neither easy nor likely to be followed by a cure.

I once advised the removal of a rapidly growing globular tumor of this kind, on the side of the neck of a boy of thirteen, which was sufficiently movable to render its ablation apparently a matter of no great difficulty. Temporary objections were raised, and, when I was asked some weeks later to operate, the tumor having meanwhile increased perceptibly in bulk, I found that I was unable to enucleate it. There was no well-defined surface to the tumor, which had become softer and very vascular, so that, in using the handle of the scalpel to discover, if possible, a limitary pseudo-cyst, blood welled up from every quarter to such an extent that I decided to close the wound and abandon the attempt to remove it. A copious watery oozing took place subsequently from several points of this wound, and this, to my surprise, continued for several days, saturating the dressings. The bulk of the tumor at the same time was diminishing very noticeably, and within a fortnight the *whole mass had disappeared.* This curious result was brought about by the wholesale death and liquefaction of the cells of which this feebly organized tumor was composed; their blood-supply had been disturbed by the attempt at enucleation of the mass, and progressive cell-death and liquefaction followed. But this event, unique in my experience, on so large a scale, was by no means final. The radical impulse to abnormal growth still remained in force, and, in about

a month or six weeks, the tumor reappeared beneath the healed and apparently healthy scar. Its growth was now even more rapid than at first. I placed the patient in my wards in the adjoining hospital, to watch him, and was soon obliged to open the trachea low down to relieve imminent suffocation from pressure; and, from persistence of this cause, he died in a few weeks.

I am not aware that there is any pathogenetic relation between adeno-sarcoma in early life and that form of scrofula which so often causes glandular enlargement at this period; nor do I believe that the use of iodine has any value, either locally or internally. The better course is early removal, when possible, as soon as the diagnosis is assured.

Pulsating vascular sarcomatous tumors are occasionally developed in the soft parts; and, when seated over the course of an artery of any size, a tumor of this kind is with great difficulty distinguished from aneurism.

In studying the class of sarcomata, we have been traversing uncertain ground as regards the question of malignancy. There is, in most cases of sarcoma, fair reason for hope that the growth may prove benign, and that in case of removal a cure may be obtained; but in the next class, which includes *carcinoma* and *epithelioma*, the diagnosis, when once established, offers little or no hope. In this class we have reason to believe that we are dealing altogether with epithelium as the cellular constituents of the tumors—*a class of cells of distinct origin in the embryo, of peculiar and possibly higher vital quality, and, when found out of their line of normal function and massed together in tumors, of more certainly malignant tendency.*

Carcinoma, or *true cancer*, presents itself in the form of a tumor, consisting, as is now asserted, of *young* epithelial cells, which may vary in appearance, but *always assume a certain characteristic arrangement in well-defined spaces known as alveoli;* these alveoli

are enveloped in and formed by connective tissue varying in density, by means of which their vascular supply ultimately reaches the cells and furnishes the means of proliferative increase.

In none of the forms of true carcinoma is there any evidence of a *tendency to develop beyond the cell-stage;* hence the inability of a cancerous ulcer to cicatrize, and its infiltrated and everted edges.

The name *epithelioma* is applied to tumors consisting of *mature* epidermic or epithelial cells, either of the pavement or columnar variety, which increase in size, become perverted from their normal function, and *finally are developed elsewhere than in the localities in which they normally belong.*

Thus, in the mucous follicles at either extremity of the intestinal canal, which are favorite seats of this variety of cancer, *the anatomical distinction between adenoma*—i. e., *a benign tumor consisting entirely of overgrown glandular epithelium, and epithelial cancer —lies in the simple fact that in the latter the epithelial cells make their appearance in the adjacent connective tissue outside of the limitary membrane of the follicle, where, normally, they are out of place*, or *heterotopic*, as it is styled. This circumstance of *heterotopy* of its constituent cells is, then, the distinctive feature of this form of cancer—*the anatomical change by which it is to be differentiated from simple adenoma.* When this change takes place, a tumor, composed of epithelial cells imbedded in connective tissue, is the result. If glandular, these columnar cells retain their natural follicular arrangement and continue to secrete. Hence this tumor never becomes very large, and is sometimes slow in progress. It is also sometimes slow in returning after removal, but it invariably contaminates the neighboring lymphatic glands sooner or later, and may reproduce itself, at a distance, in the internal organs, in the form of tumors composed of *epithelial cells similar to those of which the original tumor consisted.*

Our time will not permit further details concerning these tumors, which are fully described in your text-books; but you will have noticed that, in accordance with their pathological features, as I have sketched them, *all malignant tumors at the present time fall naturally into two classes: 1. The exceptionally malignant sarcomatous growths—sometimes spoken of as semi-malignant—of connective-tissue origin. 2. The certainly malignant true cancers—of epithelial origin.*

The advances of histology have not only disturbed and overturned former classifications of tumors, by bringing us down to a basis of anatomical structure that excludes theory, but clinical observation is daily confirming the new views concerning tumors that are opened up by this mode of studying them. Above all, it has tended to remove some of the difficulties of diagnosis and to diminish its obscurity. We have been taught, for example, that no one variety of tumor, however classified, is certainly benign; that they all, without exception, may assume the qualities of malignancy—i. e., of returning after removal, of disseminating themselves, and of ultimately producing cachexia and death; that malignancy is not determined by any peculiar shape or denomination of cell, but by *something that, in a peculiar and unknown way, perverts cell-growth and development from its normal course;* that this "something" may affect the cells of one tumor and spare those of another—composed, as far as we can see, of the same elements; that there are tumors of certain anatomical characteristics that are more likely to be thus affected—e. g., the round-celled sarcomata; others which will almost certainly escape—e. g., the lipoma and osteoma; others, again, which are sure to be mortal—as carcinoma.

It has been pretty certainly demonstrated that what is called cachexia—i. e., general loss of strength, with a pallid or yellow tint of skin from foreign admixture

with the blood—takes its origin from the local morbid growth that furnishes the material by which the blood is contaminated—a material begotten in the perverted vitality of the defective elements of the new growth; in other words, that *malignancy, as far as we can understand it, is of local and not of constitutional origin.* The clearest evidence of this is the marked improvement in health that has temporarily followed the removal of a malignant growth in so many instances. This conviction justifies the surgeon in undertaking operations upon suspicious tumors with more hope of effecting a cure, or with more chance, at least, of relieving pain, and possibly prolonging life.

But what we have learned concerning their modes of diffusing and disseminating themselves teaches, also, another lesson concerning the removal of tumors: that, to be permanently successful, an operation for the removal of a suspicious tumor must be undertaken early, and must be *very thoroughly accomplished.*

Is it desirable to explore a solid tumor by piercing it with the harpoon-like trocar devised for this purpose, with the object of examining a minute portion of it under a microscope for diagnosis? I think this proceeding rather officious, and have reason to regard it as uncertain. We have means of diagnosis sufficiently sure to render it generally unnecessary. These means consist in a familiarity with the appearance and habits of growth of tumors; their physical aspect—their color, shape, consistence, and their degree of painfulness; the time of life at which they begin to grow; the locality which they affect.

These last two circumstances are of the first importance in throwing light upon the probable nature of an abnormal growth. A soft, vivid red tumor on an infant could not well be anything else than an arterial nævus, or angeioma; a soft, bluish mass, under the same circumstances, a venous erectile tumor; a globular tumor on the head of a child, if congenital, most probably a

dermoid cyst, or an encephalocele; a tumor over the backbone, a spina bifida; at the navel, a hernia. A tumor of the lip in early life is most likely a follicular cyst; in a young woman it may be, possibly, an indurated chancre; in an old man, almost certainly an epithelioma. A tumor of the female breast under thirty is most likely a fibroma, a simple adenoma, or a cyst; at forty, a carcinoma. A sarcoma occurs, for the most part, before middle life; carcinoma, or, as it was formerly called, *scirrhus*, affects middle life, especially in women; epithelioma is a disease of age. A tumor of a jaw-bone would be a dentigerous cyst, or an osteo-sarcoma; if it grew from an alveolar margin, a myeloid sarcoma; a pulsating tumor, not over an artery, a vascular sarcoma; a black tumor, of necessity, a melanoma.

It is well to know that some solid tumors are translucent in a strong transmitted light, almost as much so as a hydrocele of the tunica vaginalis; a round-celled sarcoma of the testis would probably illustrate this fact.

The relation which tumors bear to the parts immediately surrounding them are to be closely scrutinized, in view both of their diagnosis and the propriety of undertaking their removal. A tumor that is not well defined in its outlines, that tends to blend with adjacent tissues and to infiltrate them with its substance, shows, in this circumstance, one of the most characteristic features of malignancy—i. e., the power of disseminating itself. Such a tumor is more likely to return *in situ*, and is more difficult of removal; it is necessary to cut wide of it, for there are no means of determining to what distance its cells may have wandered. On the other hand, it is equally important, when a tumor has a well-defined capsule or pseudo-cyst, to cut entirely through this external investment and reach the actual surface of the growth before attempting its enucleation, which would otherwise be attended by unnecessary difficulty.

The relation of tumors to arteries of any size, as well as to large veins and nerves, requires close attention; and there are cases in which it is wise to cut down and tie an artery which has close relations to a tumor before proceeding to the removal of the latter.

The removal of a tumor often proves to be a more serious undertaking than is anticipated, except in the hands of an experienced operator. While in many instances it is a simple and straightforward proceeding, there are cases in which all the qualities of the operator are severely taxed in conducting the operation to a satisfactory conclusion.

THE END.

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